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SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

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Editor

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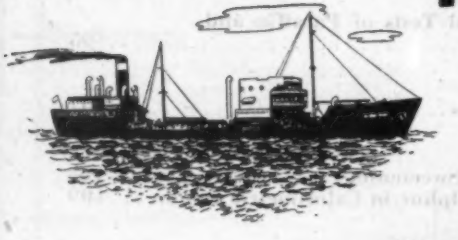

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A GULF PUBLISHING COMPANY PUBLICATION

THE LOOK BOX

HOWEVER far-fetched may seem the comparison between a pound of fresh country butter and a gallon of gasoline, it must be accepted that the production of either comes about through the workings of identical fundamentals.

Control Is Stifling

The farm has cows, grass, water, feed and a churn in the kitchen. The petroleum industry has crude oil, natural gas and processing equipment.

Each has to go to market, a routine in which they differ as distinctly as they do in production. Here, again, the means differ but the fundamentals are the same. Unless the producer can find a consumer his activity ceases. Whenever a barrier comes between the two, both the producer and the consumer suffer. Control, instead of encouraging production increase, takes its toll in reduced production.

These observations as to fundamental economics are the result of what came about following the recent OPA order whereby the point requirement for a pound of butter was raised from 12 to 16. A woman from a farm had over a period brought butter to a suburban store. After the point requirement was raised she learned from the merchant that butter sales had been so reduced that he could no longer sell her product.

The next week she arrived with the cream supply but the merchant doubted his ability to sell this. Instead he advised the woman to go about in the community and sell the cream as a raw material for butter. Repeatedly she was assured that the family was in need of butter but had no facilities for converting the cream into butter. Having over many years bought butter at the store, the customers had not needed small churns. Finally one woman took a supply of cream and attempted the conversion with an electric beater. Evidently she needed experience, since the end product was whipped cream.

Finally with the merchant standing behind a point barrier and individual users without churns, the farm woman left word with the merchant that cream, if wanted, could be had by visiting the farm. Although her price has been reduced to an attractive figure, the drain on gasoline and the wear on tires have offset this attraction.

This farm family has been forced out of the butter industry and to that extent has had its earnings reduced.

It all adds up to this: A community in which the demand for butter has for a long time exceeded the supply of butter now has still less butter as a consequence of control. Instead of more butter for the armed forces, there is less butter for both civilians and military personnel.

This trivial incident is not offered as evidence of its influence on the winning of battles over the Japanese or in the feeding of peoples in conquered or liberated countries. The butter from one farm is too little to have calculable influence.

But the viciousness of control is evident, however trivial the incident. Instead of providing more, which is desirable, it requires less, which is harmful. Simply making sure that a civilian does not have any product is no assurance that it will go elsewhere. All too often some producer simply goes out of business. Then with a smaller total of product the control authority adds more rails to its

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point barrier and the consequence is that still other producers cease to do business.

Control is a vicious tool, regardless of how and by whom imposed. A hungry and threadbare world population is not going to be relieved under a control system which hampers output. And this applies regardless of the product under control. Whether it is butter, "shoes and ships and sealing wax" or gasoline and grease.

It is production and not control that relieves shortage.

Gaining Position

IN HIS talk before Baltimore section of the Society of Automotive Engineers, William H. Elliott, paid tribute to chemical rubber and gave testimony in support of the expectation that it will gain a place in industry along with natural rubber. He said:

"Tests have clearly demonstrated that one type of synthetic rubber now being used in inner tubes is much better for that purpose than even the best natural compounds. With continued research and adequate supplies of this material available, it might supplant natural rubber in tube construction."

It is likely that this tribute was paid to Butyl rubber, which happens to come wholly from petroleum gases.

Research For Growth

THERE is a mistaken impression that only a large corporation can provide its own research organization. The fallacy of this assumption is evident from the fact that many small corporations have grown larger with the assistance of research. To accept as final the proposition that only gigantic size warrants adoption of research is to admit an unfair estimate of what research should provide.

The men who shun research because it requires substantial expenditures fail to recognize that sound information can be of as much value in small affairs as it can be in large affairs. Research will do as much for a corporation of county-wide sales as it will do for a corporation whose distribution is nationwide or worldwide.

What ownership must appreciate is that research must be styled to fit the activities of an organization. Research is after all only another tool for industry. Through it men learn how to make a new product, improve an old product or reduce costs. The man who owns a refining plant of 5000 barrels daily output has but a few products to sell. The plant chemist can double in brass and do a bit at research.

It is the attitude that counts. Men who realize that a little sound research will make a big difference in business will find the expenditure profitable. It means placing a problem before a competent worker, whether the worker has a degree in chemistry or is simply handy at tinkering.

The Only Safeguard

"PEACE is going to come to us again and we hope soon, and we hope also that it will endure for a long time. But those of us who are in positions of social responsibility in industry or in government must remember that peace is largely a state of mind of a victorious people who are one of the nations that hold the so-called balance of power and who have every interest in maintaining peace.

"We must also remember that as peace endures there is a growing tendency to believe that it is the normal state of affairs in the world, and there is a growing tendency to disbelieve that any nation would ever want to interrupt that peace. It is when that point is reached in a peaceful nation that it is at its most dangerous and vulnerable point, because then it is likely to receive a sudden blow from a nation that does not share that point of view, a nation that feels it is frustrated, a nation that will profit by war, or a nation that has been seized with some fanatical idea which drives it to form some sort of crusade in the world to force its views on other people. And it will seize a moment to strike when nations that it has to contend with are most vulnerable and most unsuspecting.

"Twice in this generation we have gone right up to the brink of war disbelieving that it would ever occur. But still war struck. And in 1941 it struck as a lightning war, a lightning war which nearly succeeded and would have succeeded with a little better planning and a little more thorough preparation. It would have succeeded because of the development of lightning weapons, developments that had taken place in the preceding twenty years.

"The development of weapons, as we engineers all know, proceeds from the general availability of scientific knowledge, an availability that is world-wide, and is distributed through media that are world-wide, such as scientific papers, and publications of various sorts.

"In the next world war, which will inevitably come some day, but we hope not in our lifetimes, the linghtning war will be much more feasible, because of the rapid development that is taking place and that cannot be stopped, and that will be world-wide. The only safeguard against it by a free and peaceful people such as ourselves is to be so far ahead in our progress that no nation will take the risk of attacking us."

From the remarks of R. E. GILLMOR, *President, Sperry Gyroscope Company, before the forum "The Future of Industrial Research."*

PROOF that Edward streamlined flow cuts pressure loss, saves money

Here's evidence that pressure loss through your small globe valves can be greatly reduced, or that greater volume of flow can be had with the same pressure loss, by standardizing on Edward 60° stem forged steel globe valves.

See the result of Edward Valve streamlining in less turbulence, higher efficiency and maximum volume at the equipment where it's needed.

$$h = \frac{1}{K^2} \cdot \frac{w^2}{1891^2 \, D^4 \, \rho}$$

THIS formula for computing pressure drop is based on material presented in *Fluid Meters—Their Theory and Application.** Provided the value of K is known, pressure drop through any valve can be calculated accurately. K is a factor dependent upon the general shape and contour of the valve and is determined by experimentally measuring flow and pressure drop through the valve. If resistance to flow is low, K approximates 1; with high resistance to flow, K approaches 0. Values for K, shown below, for Edward Fig. 2688 type valve and typical ordinary forged steel globe valve were determined through experiments on Edward flow test lines.

*American Society of Mechanical Engineers, 1937.

h—pressure drop through valve, psi.

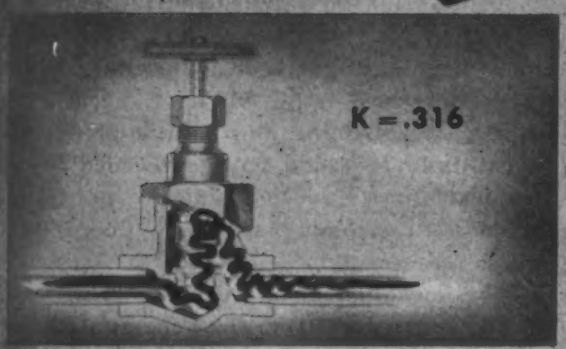
K—valve (or flow) coefficient.

w—weight of fluid through valve, lb/hr.

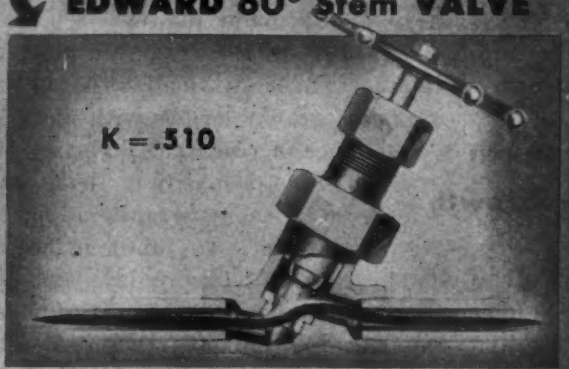
D—nominal pipe size.

ρ—density of flowing fluid, lb/cu. ft.

"X" VALVE



EDWARD 60° Stem VALVE



Steam . . . 10,000 lb/hr, 740 F, 525 psi, 2" line

$$h = \frac{1}{.316^2} \cdot \frac{10{,}000^2}{1891^2 \times 2^4 \times .797} =$$

h (pressure drop, psi) = 21.9

$$h = \frac{1}{.510^2} \cdot \frac{10{,}000^2}{1891^2 \times 2^4 \times .797} =$$

h (pressure drop, psi) = 8.44

Water . . . 50,000 lb/hr, 300 F, 900 psi, 2" line

$$h = \frac{1}{.316^2} \cdot \frac{50{,}000^2}{1891^2 \times 2^4 \times 57.4} =$$

h (pressure drop, psi) = 7.65

$$h = \frac{1}{.510^2} \cdot \frac{50{,}000^2}{1891^2 \times 2^4 \times 57.4} =$$

h (pressure drop, psi) = 2.94

Sharp turns in flow cause excessive turbulence (which promotes valve wear) and increase pressure drop (which wastes power). Edward 60° stem valves ease flow through with no sudden changes in direction.

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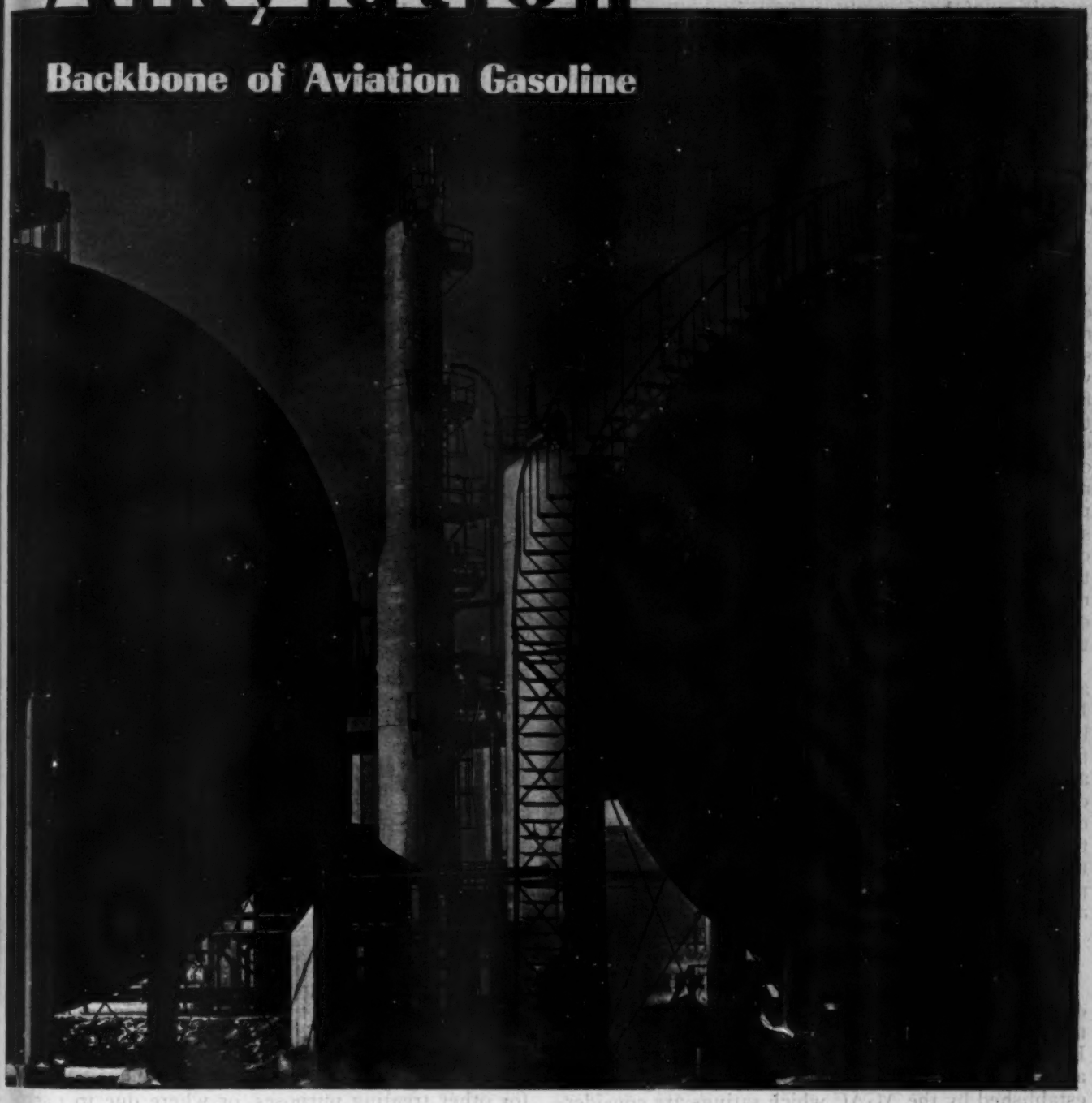
Alkylation

Backbone of Aviation Gasoline



IT requires no imagination to realize what an important part aviation gasoline has been and is playing in the present war, the author told his hearers in presentation of this paper before the Chicago War Production Conference, March 29, 1945. "We get daily reminders, ranging from spectacular mass attacks on the enemy to the scouting missions of lone planes, and the flying of wounded from battle zones. Great quantities of planes, fuels and lubricants, and considerable manpower are required for these accomplishments.

"Before our entry into the war, production of aviation gasoline of war grade was around 40,000 barrels daily. Since then, and through the concerted efforts of the petroleum industry and the war agencies, war-grade aviation gasoline has been increased over ten fold to approximately 500,000 barrels daily."

Photograph on this page shows alkylation unit in the Sinclair Refining Company plant at Sinclair, Wyoming.

WILLIAM MENDIUS
Sinclair Refining Company

THE aviation gasoline used by our armed forces is a blend of many hydrocarbons of the C_5 to the C_{10} range from the paraffin, aromatic, naphthene, and olefin series, plus tetra-ethyl lead. With minor exceptions, these hydrocarbons are not blended as individual compounds but exist as components in the various types of stocks which are blended for finished aviation-gasoline production. These stocks are classified under two groups, namely, base stocks and blending agents. The base stocks which have octane ratings on the low side of the pattern consist mainly of materials produced by catalytic cracking and from straight-run sources. The blending agents which have

octane ratings appreciably higher than aviation gasoline and consequently have the power to carry larger quantities of base stock, consist in major part of alkylate, together with minor quantities of hydrogenated codimer, hydrogenated acid polymers, and aromatics. Alkylate may therefore be rightly claimed to be the backbone of aviation gasoline since its production is sizable, and since it has octane ratings appreciably higher than the current standard for war-grade aviation and consequently is able to carry quantities of the base stocks considerably in excess of its own volume.

Alkylation

Alkylate as herein discussed is that product falling within aviation boiling-point range produced by the exothermic reaction of one or more of such unsaturates as propylene, butylenes, amylenes, or condensation products from the polymerization of butylenes with isobutane, using either sulfuric acid or hydrofluoric acid as a catalyst. The reaction is not simple, the final aspects of which have not as yet been firmly established. In addition to the simple coupling of the olefin and isobutane, it has been postulated that isomerization, dehydrogenation, and hydrogenation take place as side reactions. However it is not within the scope of this discussion to deal further with the intricate mechanisms involving these reactions. Basically the alkylation process effects the combination of one mol of isobutane with one mol of the $C_3 - C_4$ or C_5 olefin or its equivalent in the form of olefin polymers to form one mol of alkylate.

Commercial alkylation was started in this country around 1938. These early plants used sulfuric acid. It was not until after our entry into the war in the latter part of 1942 that the first commercial hydrofluoric plant was put into operation. Today there are in the neighborhood of 60 alkylation units in operation producing approximately 130,000 barrels daily of aviation alkylate. Of these, about 60 percent are of the sulfuric-acid type which account for around two thirds of this production. The hydrofluoric units comprise about 40 percent of the total and take credit for approximately one third of the overall production.

Above Rated Capacity

As a whole these commercial units are really delivering the goods. Approximately 75 percent of them are exceeding their original design capacities. In fact, better than 25 percent are producing alkylate at a rate exceeding the maximum capacity ratings established by the AGAC which ratings are considerably in excess of design. The oil industry is not resting on this record. Continued thought and effort is being exercised to further increase production and quality by increasing the supply of raw materials, by extending operating efficiency, and by improved operating technique and "know-how."

Alkylate is produced commercially in all types of units by very intimately mixing the feed stocks containing the olefins and isobutane, in as high a concentration as practical, with recycle isobutane and acid catalyst at a controlled temperature. This mixture is then routed to a settler where the acid is settled out for reuse, with adequate facilities provided for the maintenance of proper acid strength. The acid-free hydrocarbon product is passed through a series of distillation operations to recover, with minimum loss and at high concentration, all unreacted isobutane which is used as recycle, to reject all other saturated hydrocarbons, which occur as contaminants in the raw feed stocks and which are not desired in aviation gasoline, and to make the proper separation of the alkylate produced into aviation alkylate and so-called heavy alkylate.

It is not the intention of this discussion to deal with the relative merits of the several types of equipment used in the alkylation units currently in operation. A general review of the characteristic differences involved when using the two acid catalysts previously mentioned, and of the operating problems and use of material, is considered to be in order. Unfortunately there are certain limitations which must be observed in this discussion because of the necessity of wartime secrecy.

Operation Difficulties

Because of longer operating experience, sulfuric acid alkylation units have encountered fewer operating and maintenance difficulties than the hydrofluoric units. Also, under the operating conditions involved, sulfuric acid is less corrosive to commercial equipment than is hydrofluoric. Another point of difference is that acid-catalyst regeneration is not employed directly in connection with a sulfuric acid alkylation unit, whereas this operation is an integral part of an hydrofluoric alkylation plant.

In sulfuric-acid alkylation no consistent operational troubles are being encountered. Acid settling difficulties have been experienced from time to time which are largely a result of insufficient settling time because of extended unit throughput, or the use of fresh acid which contains too high a concentration of carbonaceous material when such acid is obtained by certain regeneration processes used in reclaiming spent acid, or the formation of too tight an acid-hydrocarbon emulsion in the reaction phase of the process due, in some cases, to obscure emulsifying agents.

Sulfuric acid of 95 to 99 percent strength is used as fresh acid supply. Such acid is either clean white acid, or regenerated acid produced by the hydrolysis and concentration of spent acids from the alkylation process or from light oil or lube oil treating operations. The concentrated acid muse then be fortified with fuming acid to bring it up to the strength suitable for alkylation purposes. Acid is rejected at strengths ranging from 85 to 91 percent titratable acidity. Reduction in acid strength is due partially to hydration and partially to formation of acid tars. In cases where the rejected spent acid cannot be used for other treating purposes, or where due to uneconomical transportation it is not feasible to regenerate it, disposal of alkylation spent acid is a problem.

Reaction Temperatures

Reaction temperatures range from 40 to 70° F., depending on the ratio of production rate to refrigeration capacity and on the efficiency of the cooling systems, particularly during the summer season when cooling water temperatures are generally high. Removal of the exothermic heat of reaction at these temperatures is effected by indirect cooling using standard compression or absorption refrigerating systems employing ammonia or a hydrocarbon gas, such as butane or propane, or by auto-refrigeration wherein the heat is carried away by the partial evaporation of the lighter hydrocarbons in the reaction zone.

The sulfuric-acid plant employs no special engi-

neering materials. Carbon-steel equipment is used throughout. Very little corrosion is encountered except in special cases.

As pointed out earlier, hydrofluoric alkylation operations have given considerably more trouble. However the hydrofluoric "know how" is being rapidly acquired and it should not be long before most troublesome factors will be overcome. At the present time many of the problems have been solved.

Handling of Hydrofluoric Acid

Physically, hydrofluoric acid differs appreciably from sulfuric acid. At strengths employed in alkylation, hydrofluoric acid is a volatile liquid at ordinary temperatures and hence must be stored in pressure vessels. It also possesses a certain degree of solubility in the hydrocarbons processed. Because of its volatility it readily lends itself to regeneration by distillation, thus making possible a very low consumption. This volatility also requires that rigid precautions must be observed constantly to prevent even minute leakage to the atmosphere for economic and safety reasons, since hydrofluoric acid is very toxic.

Hydrofluoric acid is charged to the alkylation unit in a practically pure state. No acid is rejected from the unit except by loss. A system acidity of 85 to 91 percent is maintained in the unit by the continuous regeneration of a split stream of the circulating acid. Such regeneration removes both water and acid tars. Acid consumption is very low, being less than 5 percent compared to sulfuric-acid consumption. Loss by system leakage, or because of shutdowns, accounts for the major part of this consumption, which will be materially reduced as operating problems are overcome.

Reaction temperatures range from 70° to 110° F. and are controlled by the use of cooling water, in the majority of cases.

Certain problems have been encountered in hydrofluoric alkylation operations. There have been no difficulties with acid settling. However, because of the solubility of hydrofluoric in hydrocarbons, two additional processing steps in handling the effluent hydrocarbons are required in this process as compared to the sulfuric process. First a stripper is necessary to eliminate substantially all of the free dissolved hydrofluoric and also the majority of the organic fluorides from the hydrocarbon reaction product. Free hydrofluoric is removed by simple distillation and the fluorides are broken down to free hydrofluoric by the elevated temperatures employed aided by the catalytic action of the materials used as tower packing. Some problems, notably loss of free hydrofluoric due to faulty stripper operating technique, plugging of packing, and unsatisfactory fluoride removal have been encountered from time to time. However satisfactory progress is being made on these problems.

Secondly, stripper bottoms, even with what so far has been termed acceptable hydrofluoric and fluoride removal, still contain more of these materials than is desirable to handle in the conventional distillation equipment of an alkylation unit because of their influence on corrosion and also on contamination of alkylation products. To correct this situation, a treater is provided to remove these residual fluorine compounds. Calcined bauxite is the most commonly used treating agent, but this has been found troublesome. Other treating agents are being tried but results so far are inconclusive.

Hydrofluoric Regeneration

The regeneration of spent hydrofluoric has also imposed some operational problems. Removal of free hydrofluoric by distillation from the acid-tar bottoms has not been generally satisfactory. Also, these bottoms contain some fluorides, which result in a disposal problem. Reprocessing of this stock in the refinery is not considered advisable because of the fluorine content thereof.

Because of its fuming nature and toxic properties, it is necessary that hydrofluoric escape to the atmosphere be minimized. Hydrofluoric causes severe burns on living tissue and is particularly bad if inhaled. Ample precautions have been taken and safety measures have been followed, and it is gratifying to state that very few accidents have occurred. Hydrofluoric-alkylation-plant design includes provisions for flushing out all equipment containing the acid before such equipment is opened up for inspection and repair. When flushed out or dumped from the system as much acid as possible is collected in pressure storage vessels for reuse. Residual acid or that which is vented is substantially neutralized by an alkaline solution allowing a minimum amount to be released to the atmosphere at some point where least nuisance will result. In addition many precautions are taken for protecting operating and repair personnel against accidental contact, as well as providing curative measures in case of exposure.

Hydrofluoric acid in the concentrations existent in the alkylation unit, excepting the regeneration equipment, is generally not corrosive to vessels and piping made of carbon steel of the type ordinarily used in refinery equipment. One of the most troublesome problems which has been experienced concerns plug valves in acid service. These valves, which require at least some dissimilarity in mental characteristics between plug and body to insure tightness, have been almost universally subject to severe stress corrosion cracking causing fracture when carbon steels are involved. Developments in progress for relieving this condition involve the use of non-ferrous coatings of plug and body, such as monel, and there is promise of great improvement.

Corrosive Properties

Another phase where improvement in material selection is under development is in the acid regenerating system, particularly the fractionating tower. More corrosion is encountered here than elsewhere due to the presence of water diluted acid at elevated temperature. The use of various alloy linings, including silver, copper, and monel, have met with indifferent success. Of the three, monel appears to be preferable. It is not unlikely that a steel tower with sufficient corrosion allowance may be the best solution on a "take it and like it" basis.

It is essential that neither cast iron or glass be used in any service exposed to hydrofluoric because of their silica content, which element is generally attacked by the acid. The necessary absence of gauge glasses has resulted in the use of some ingenious devices for determining liquid levels in vessels. Packing of pumps and protection against corrosion on instrumentation, when in contact with acid, requires special considerations.

Alkylation hydrocarbon feed stocks, particularly those containing the olefins, all contain sulfur contaminants such as hydrogen sulfide and mercaptans, the concentrations of which depend on the source of

crude processed, the type of olefin being alkylated, and the degree of pretreatment, if any. These contaminants result in increased spending of the acid catalyst, particularly in the sulfuric-acid process, and in the production of a non-acceptable corrosive alkylate. It is therefore a sound practice to caustic pretreat all feed stocks for substantially complete removal of these sulfur compounds.

Moisture Removal

All hydrocarbon feed stocks also contain some moisture which causes spending of the acid catalyst. In most sulfuric-acid units water removal is not practiced since the water dilution is not a material spending factor at the acid replacement rates presently employed. On the other hand, substantially all hydrofluoric alkylation units have equipment for maximum removal of moisture in feed stocks, since any water introduced must be subsequently removed in the acid regeneration step. Water removed by regeneration results in a loss of hydrofluoric and materially affects the corrosion rate of this equipment.

Each olefin, namely propylene, the butylenes, amylenes, cold-acid isobutylene polymers, and codimers, commonly being charged to alkylation units, produces an aviation alkylate differing somewhat in quality and yield. Because of the variable effect of the significant reaction factors on these several olefins, the relative merits of these can only be generalized. Likewise a discussion of the reaction factors can, on this occasion, only cover general trends.

Alkylate Produced

In sulfuric-acid alkylation the order of preference, as far as quality of aviation alkylate produced from the olefins is concerned, is, generally speaking, as follows: butylenes, isobutylene polymer, codimer, amylenes, and propylene. In hydrofluoric alkylation the order is not exactly the same, in that propylene produces better alkylate than do amylenes. It may be stated, in this connection, that acid consumption or acid regenerating requirements usually occur in inverse order to those given above.

Alkylates produced from the different olefins also differ in boiling range. Propylene alkylate has the lowest boiling range predominating in the C_7 and C_8 level. The boiling range for butylene alkylate is somewhat higher and is concentrated in the C_8 group. Amylene alkylate has the highest boiling points following the C_8 and C_9 hydrocarbons. These characteristic differences naturally tie in with octane quality, and also play an important part in final boiling range of aviation gasoline.

Yields of aviation alkylate on olefins consumed exhibit the same trend for both sulfuric-acid and hydrofluoric-acid alkylation. For the simple olefins, propylene through amylenes, aviation alkylate yields fall off with increase in molecular weight of the olefin, ranging from approximately 170 to 145 volume percent. Although the complex olefins, that is those obtained by previous polymerization, tend to follow the characteristics of their parent olefins, aviation alkylate yields therefrom may be somewhat lower because of the possibilities of a greater variety of side reactions.

Time and Temperature

The significant reaction variables include that well-known team of time and temperature, and also isobutane concentration, ratio of acid catalyst to hydrocarbons, and titratable acidity of the catalyst. In commercial operation these factors are more or less interlocked and hence optimum conditions for each can rarely be achieved, especially at the current high production rates. Operating conditions usually are selected to give the best overall result, which generally is defined as maximum 100-octane aviation gasoline production. This is usually accompanied by some degradation in alkylate quality. For instance, when increasing alkylate production in any given unit, reaction temperature as well as time are usually adversely affected, and if this unit utilizes hydrofluoric catalyst, regenerating equipment may be overloaded, which adversely affects the acid strength factor. Also desirable increases in isobutane concentration and in acid-hydrocarbon ratio results in depreciation of time factor effect.

As in many chemical reactions, increase in time factor gives improved results particularly as regards quality of alkylate. For practical operation there is a minimum time limit below which unsatisfactory results are obtained. Also increase in time factor above some upper limit will result in only minute, and hence uneconomical, improvement. Alkylation units have been generally designed to approach the upper limit, thus permitting them to materially increase plant throughput as increased olefin supply was made available.

It has previously been indicated that the optimum temperature plane for sulfuric-acid alkylation is materially lower than for hydrofluoric alkylation. The general rule applies that alkylate quality improves with reduction in temperature within certain limits, but the relationship of rich octane rating quality does not necessarily behave like that for lean octane rating quality.

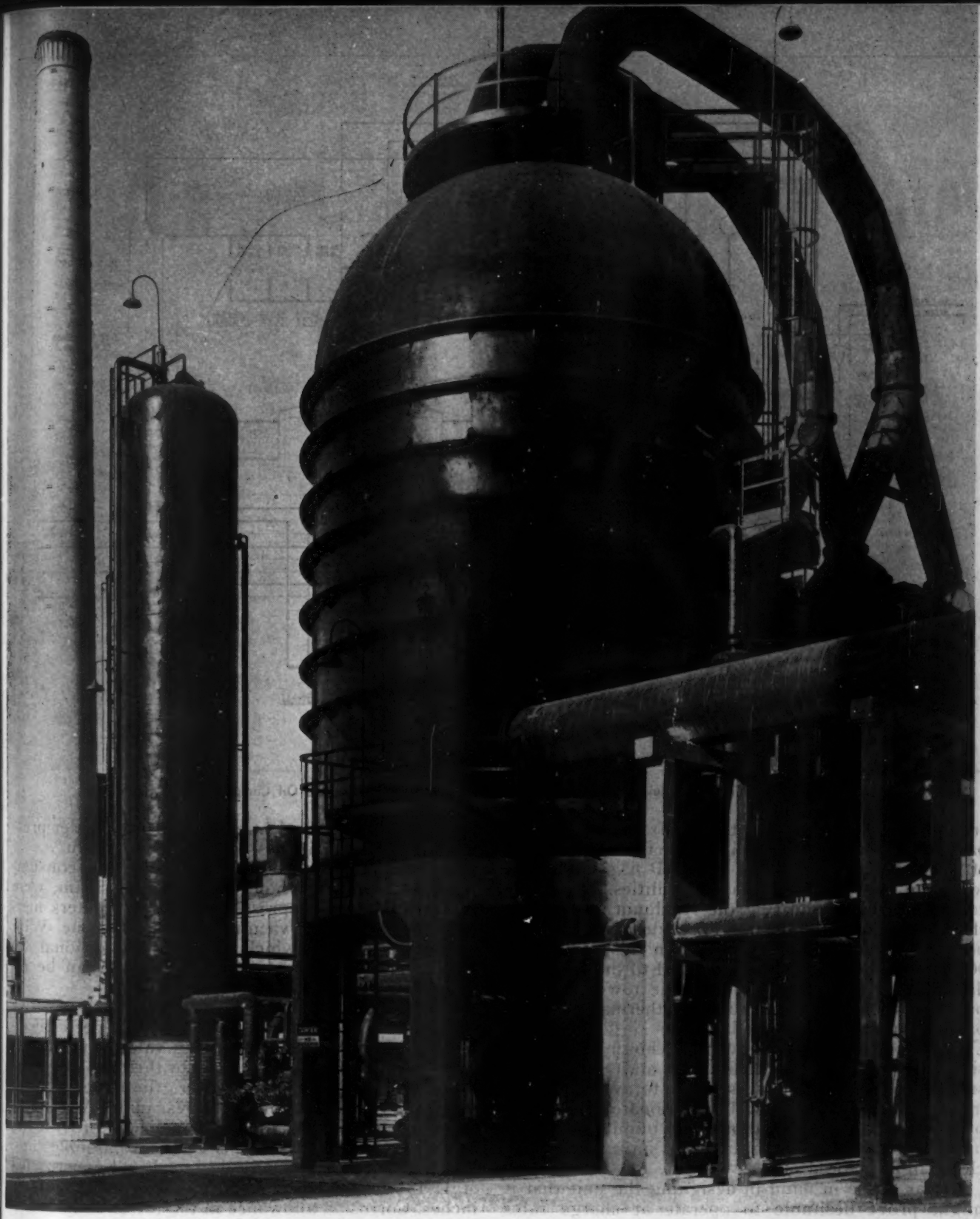
The alkylation reaction is promoted by high isobutane concentrations, which has a beneficial effect on quality. Consideration of isobutane concentration deals with ratio to diluents such as propane, butane, and pentane, as well as with ratio to olefins.

Acid Strength

Acid strength plays an important part in the quality of alkylate produced. When using sulfuric acid, alkylate quality is a direct function of acid strength employed. Catalyst consumption is also in direct proportion to this factor. Obviously, for economic and supply reasons, the higher strengths cannot be commercially employed as the fresh acid make-up rate becomes excessive. In the hydrofluoric process there is evidence that an optimum strength favors the rich octane rating but variations therefrom have little effect on lean rating.

With either acid catalyst improved results are obtained with increasing ratios of acid to hydrocarbons, or percentage acid in the reaction mixture. About 50 percent acid is usually considered a minimum. For sulfuric acid there appears to be a ceiling above which a tendency is exhibited to form tighter emulsions in the reaction zone, making acid settling quite difficult. No ceiling is as yet known for hydrofluoric. This acid is more fluid and hence does not have the emulsifying characteristics of sulfuric acid.

According to reports, there may be a possibility of producing a super aviation fuel in which alkylate may play a part even more important than it does in the current grade. When and if this materializes, the oil industry will be prepared to meet the requirements in the same record manner that has signalized its accomplishment in supplying the current requirements.



Tide Water's Special Unit Prepares Feed for Fluid Catalytic Cracking

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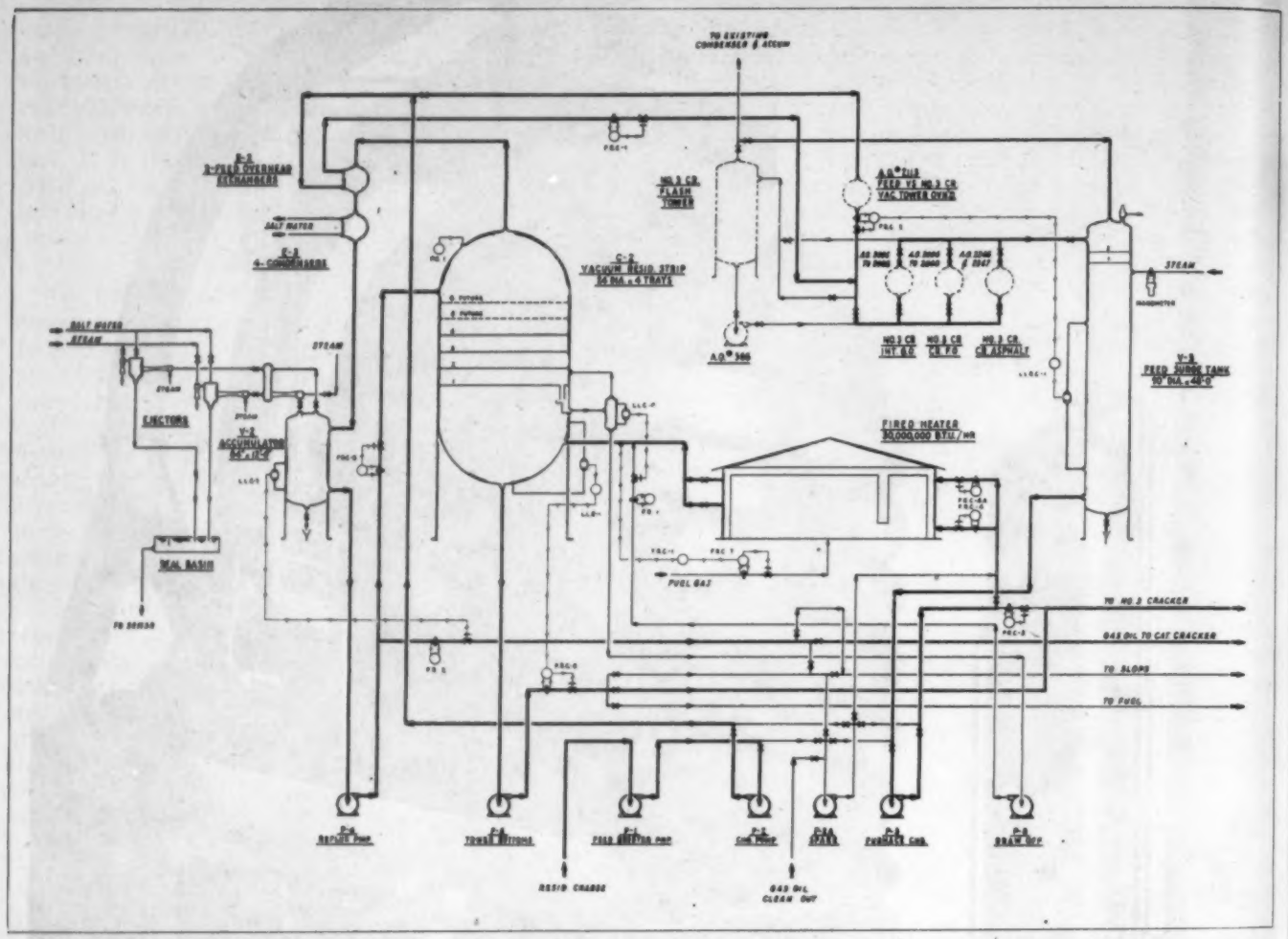
IN ORDER to augment the quantity and control the quality of gasoil feed stocks to a large new Fluid Catalytic Cracking Plant, a Vacuum Feed Preparation Unit has been installed at Tide Water Associated Oil Company's Avon Refinery.

The new unit consists of a gas-fired tubular heater, a combination steam stripper and furnace charge surge tank, a 24-foot diameter four-tray vacuum flash tower, condensers, heat exchangers, reflux accumulator, and twin 2-stage vacuum ejectors plus booster ejector. The vacuum tower is 22 feet high on the straight side section and has a hemispherical top



Flow chart of feed preparation unit, fluid catalyst cracking project, Tide Water Associated Oil Company, Avon, California

and bottom. It is designed to distill overhead 10,000 barrels per day heavy gasoil product from a charge of 25,000 barrels per day of 19° A. P. I. straight-run residuum from crude distillation facilities. This is accomplished by pre-heating the residuum in heat exchangers followed by heating to the desired flash temperature in the gas-fired furnace. In this heater 50,000,000 Btu per hour are transferred to the oil. After distilling off the gasoil product, the tower bottoms product is charged to an adjacent thermal viscosity breaking unit without cooling.

The diameter of the tower was chosen after considerable study, both theoretical and of existing smaller commercial units, in order to avoid entrainment, and produce a well fractionated overhead product. Seventy-five gallons per minute reflux is used, and the overhead product is an exceedinngly clean, light colored oil.

It was borne in mind in designing the unit that it might prove desirable to operate at charge rates somewhat less than under present wartime conditions, and by cutting deeper into a smaller charge of residuum, maintain overhead production at 10,000 barrels per day. To insure this flexibility in operation, the booster steam ejector was incorporated in the vacuum ejector system, and additional precautions were taken to install heater tubes and transfer lines of adequate size in order to minimize heater outlet pressures. The increased vaporization obtainable permits a substantial heat transfer rate with heater outlet temperatures not in excess of those which would cause cracking. Accordingly, a 10-inch heater outlet header expanding into a 24-inch then a 36-inch transfer line was chosen, with resulting heater outlet pressures of 10 to 15 inches of mercury vacuum.

The twin 2-stage vacuum steam ejectors, consuming 4500 pounds per hour of 235-pound steam, were designed to create a pressure of 50 millimeters mercury absolute in the vacuum tower flash zone. With the booster ejector, which requires an additional 800 pounds per hour of steam, this pressure can be reduced to 30 millimeters.

The gas-fired furnace has 5900 square feet effective tube surface and operates at or above 65 per cent efficiency based on fuel-gas heating value when transferring 50 million Btu per hour to the oil.

The 36-inch transfer line enters the tower tangentially, the feed impinging on a wear plate. A feed distributor employing the baffle principle is provided in the vacuum tower flash zone. The trays, bubble caps, and risers are all specially designed and constructed of 11-13 chrome stainless steel. Tray spacing is 36 inches. Corrosion allowance in the tower body is 1/4-inch. Overhead vapor lines, of which there are two, are 36-inch. These lead to two parallel 2100-square-foot heat exchangers and are followed by two parallel water-cooled total condensers, each having a surface of 4200 square feet. The presence of liquid on the bottom tray of the vacuum tower is insured by observation of a side draw stream from this plate which is recirculated by a pump back to the tower inlet. Control of the unit is fully automatic.

The unit, which was constructed to Tide Water Associated Oil Company's specifications by C. F. Braun and Company of Alhambra, has performed satisfactorily, fulfilling all expectations.

Commercial Values and Physical Tests of

Paraffin and Micro-Crystalline Waxes

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THE physical constants such as the solidifying point, density, ductility, etc., depend upon the molecular weight and the structure.

The paraffin waxes are classified into three classes, viz., slack wax, semi-refined wax (single deoiled) and fully refined wax (double deoiled).

The slack wax is the cheapest and is used commercially in compounding with other materials. The semi-refined wax which contains a small amount of oil is used where a softer wax is required. The fully refined wax which is practically free from mineral oil and odor has a higher melting point and the greater tensile strength.

The present melting point which is really a "setting point" is between 130° F. to 132° F. on the semi-refined, and 134° F. on the fully refined wax. This wax is also more transparent and has a higher gloss or luster than the semi-refined wax. The structure, melting point, odor, etc., of these waxes depend on the source of the crude oil and the refining methods used. These paraffin waxes can be combined with the new micro-crystalline waxes forming a more ductile wax, especially if a small amount of amorphous wax (petrolatum) is added.

The melted paraffin waxes when poured into a shallow mold show a mottled appearance on cooling, while the micro-crystalline waxes, especially when mixed with each other or with a paraffin wax or if they contain a soap, show a pattern of daisy-like crystals or some other pattern, depending on the mixture as shown in Figure 1. (No. 23 launching base coat.)

Figure 2 shows brittle or rather cheesy breaks when subjected to a 3-ton load at 87.8° F. temperature, while Figure 3 shows a nearly perfect mold with the same pressure but at 97° F. temperature, which is obtained by adding a small amount of suitable soap and some paraffin wax to the micro-crystalline wax shown in Figure 2.

Micro-Crystalline Waxes

These waxes are obtained by different refining processes than the old method and are not pure white, but when filtered or treated are nearly white with a slightly yellow cast. The regular micro-crystalline waxes are light cream to dark tan in color and can be had in dark reddish brown or black. They have different melting points and penetrations.

Some of the hard micro-crystalline waxes do not show any greater strength than the fully refined waxes, but have higher melting points. Their structure, when cold shows a somewhat different grain than that of the ordinary white wax. When poured into shallow molds at about 200 or 220° F. they show,

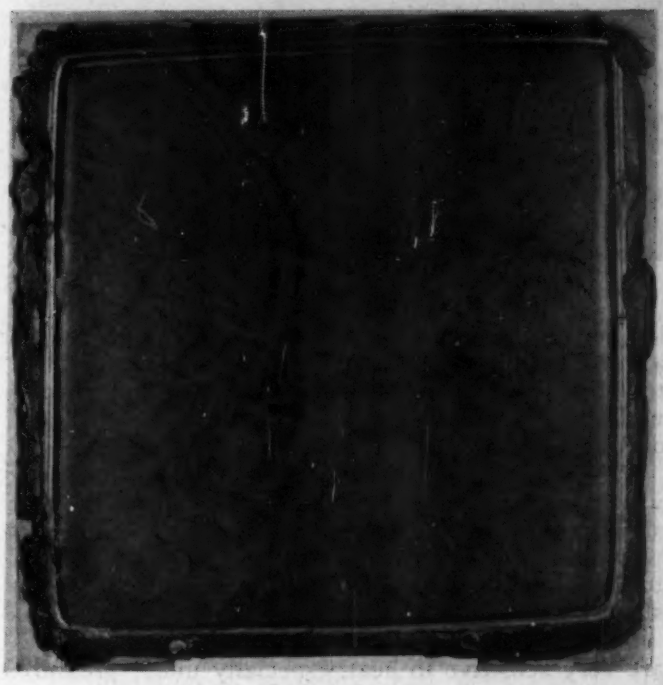

FIGURE 1

on cooling, a certain pattern of crystallization and differ from one another the same as paraffin waxes.

Other types of waxes require such tests as, specific gravity, luster, viscosity, oil content (California method), solubility in various solvents, load-carrying and adhesion tests, refractive index, softening point (R. & B.) acidity, and iodine number.

Ductility, Adhesion and Wire Cone Melting-Point Tests

The ductility or bending test is made with a trimmed strip of wax 5-32-inch thick by 1 inch wide by 6¼ inches long, and is supported by a strip of

Comparative Tests on Paraffin and Micro-Crystalline Waxes

	Semi-Refined Paraffin	Fully Refined Paraffin	Micro-Crystalline Wax
P. M. P.	130-132° F.	134.0° F.	171.4° F.
Spl. Wire Cone M. P.	180.5° F.	200.0° F.	203.0° F.
Color	25	30p	6p
Tensile Strength	150	220	220
Odor	O.K.	O.K.	O.K.
A.S.T.M. Penetration:			
Cone 150 grms. at 77° F.	5	3	3
Cone 300 grms. at 77° F.	10	7	12
Needle 150 grms. at 77° F.	26	18	18
Ductility Test at 100° F.	O.K.	At 100° F. O.K.	At 105° F. O.K.
Ductility Test at 95° F.	Cracks	At 95° F. cracks	At 100° F. cracks
Ductility Test at 90° F.	Breaks	At 90° F. breaks	At 95° F. breaks
Weight per Gallon	6.396 lbs.	6.399 lbs.	6.667 lbs.

FIGURE 2

FIGURE 3

leather of the same dimensions. Both are cooled in a water bath to test temperature ranging from 105° F. to 90° F. for the paraffin and micro-crystalline waxes, while the compounded waxes range from 95° F. down to 45° F.

When the proper bath temperature is reached, the wax strip supported by the leather strip is bent slowly downward over a ¼-inch round wood pin which is fastened to the wall and the strip is bent to an angle of 180 degrees. No breaks or cracks should appear at certain specified temperatures.

The paraffin as well as the microcrystalline waxes are very sensitive to heat, especially under pressure. The slightest change can be recorded by means of a special lever type machine or press.

For ship-launching base coat, a pressure of 3 long tons per square foot is applied after sample has been brought to the desired temperature, preferably overnight. One hour under this pressure and at 85° F. or as high as 88° F. temperature will extrude from 0.5 to 18 percent, which should be the maximum in extrusion at 88° F.

These waxes must also be adhesive to wood and must therefore stand 30 to 35 pounds per square inch pressure before coming off the wood. A poor product will break off with the least pressure while a good adhesive product will shear off rather than come off clean from the wood.

These waxes may also be compounded with certain soaps which give them better adhesion and higher load-carrying properties.

The present melting point of these waxes is really a "setting point." A true melting point, the same as used on some bearing greases (wire cloth basket) may be more desirable because it gives from 35 to 45 degrees higher readings.

A wire cone of 50 mesh wire cloth (nickel), 1⅞-inch diameter by 2¾ inches long is used. A prepared sample is first formed in a No. 1 Coor crucible, which holds 20 to 22 grams. This melted wax is cooled to room temperature and chilled, removed from the crucible in one piece and placed in the wire cone. The cone has a 3-pronged support and is set over a beaker and heated slowly about 3 degrees per minute in an oven (similar to the old square copper oven) equipped with 2 opposed glass windows and a small electric lamp so as to observe the first drop. When the first drop falls, the thermometer temperature is recorded as the melting point. The themometer is in the center of the oven and close to the beaker and wax but not touching either. Waxes now quoted as having 170°-180° melting point will go as high as 203° F. to 220° F. before the first drop comes off, which is the true or actual melting point of the wax.

Commercial Uses

These waxes can be used straight or combined with other raw hydrocarbon products, in such products as:

Aluminum waxing (anodized).
Aqueous paraffin emulsions for use in sizing of paper and cotton textiles.
Automobile polishes.
Belting manufacture.
Candle manufacturing.
Cheese wrappers.
Cosmetic bases.
Carbon paper.
Crayons.
Dental waxes.
Ductile sealing waxes.
Electroplating.
Electric insulations.
Emulsions (soluble in water) to coat apples, citrus fruit and other food products.
Fatty acids.
Floor waxes, liquid, paste and powdered.
Fruit and food preserving of jellies and other canned goods.
Impregation of fabrics in stencilling and dyeing.
Inks.
Leather dressing.
Match industry.
Modelling waxes.
Oil and soap products.
Paint manufacture.
Paper manufacturing and finishing.
Plasticized waxes.
Paste waxes.
Polishes.
Rubber—HCL to improve elasticity.
Rubberized textiles.
Salves and ointment bases.
Ski waxes.
Waterproofing for cloth or wood.

Shale Oil Emulsions and Sludges

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Glen Davis, N.S.W.

THE problems encountered in the retorting of the torbanites of New South Wales are especially significant now because of the experiments about to be undertaken in the United States. Through the Bureau of Mines the shale beds on government-owned property in Colorado will be worked for the purpose of revealing reserves of liquid fuels in the shale beds of the nation.

This article has been divided into two main sections:

Factors influencing the formation and stabilization of emulsions;

Treatment of the emulsions and sludges.

A list of the special analytical methods used in the work has been prepared as an appendix.

ALTHOUGH considerable literature on shale and shale oil has been published, very little of it relates to operational difficulties experienced on large-scale work. In particular there is little mention of the troubles experienced in condensing the oil vapors from the retorts.

Product plants for handling these vapors seldom are designed with the idea of minimizing or avoiding the emulsion formation which appears to be an inherent factor in the process. Rather is it more usual that such problems have to be faced on the spot when the difficulty arises.

The composition of the oil obtained by destructive distillation of oil shale depends on several factors, the most important of which appear to be the type of retort and the retorting conditions, together with the type and quality of the shale. The torbanites of New South Wales, when subjected to low-temperature carbonization, give a highly paraffinic oil,[1] if excessive secondary cracking is not promoted. The oil used in this work was produced from a bench of Pumpherston retorts, modified from those used in Scotland by the downward internal extension of the gas offtake.

Formation and Stabilization of Emulsions

In this work the term "emulsion" is applied to any mixture of oil and water that does not separate readily. In these emulsions the oil is always the continuous phase and the water usually is present as large drops readily visible to the naked eye.

From examination of the emulsions obtained on the plant it was obvious that several factors must be operating to give the wide range of emulsion stabilities encountered. In plant practice the following were found to be of major importance and are discussed in the order:

a. Nature of oil;
b. Extent of mixing or degree of emulsification;
c. Temperature;
d. Solids content of the oil;
e. Water content;
f. Storage of the oil.

Generally speaking the ease of emulsification increases with rise in specific gravity of the oil. This is due to a combination of factors; probably viscosity plays an important part since the oil is the continuous phase in these emulsions.

Degree of Emulsification

The degree of emulsification obviously is dependent on the amount and nature of the mixing to which the oil and water are subjected in handling. Excessive mixing naturally gives, within limits, a finer emulsion, and the finer the droplets of the disperse phase the less readily will they coalesce and separate out.

Woelflin[3,4] points out that, in general, the tighter emulsions are the more difficult to dehydrate. Pumps causing the least amount of re-emulsification should be used when handling mixtures of oil and water.

The effect of mixing is illustrated by a comparison of Tests 18 and 19 (Graph 1). Test 18 was shaken up in a 2-liter graduate while Test 19 was shaken up in a 250 ml. graduate, all other emulsification conditions being the same. The smaller graduate induced a more vigorous agitation than the other and the resultant emulsion, being more finely dispersed, took longer to break even at the slightly higher temperature at which it was held.

Examination of numerous emulsions lead to the conclusion that no universal correlation could be found between the amount of water separated and the time required for the separation. Stokes' law states that the velocity of sedimentation of a spherical droplet varies directly as the square of its radius. Consequently the larger drops of water naturally separate faster than the smaller ones and therefore no such correlation could be expected unless the size distribution of the water droplets was the same in all the emulsions.

Temperature

The viscosities of oil and water decrease with increase in temperature. Such change permits more rapid sedimentation and coagulation of the disperse phase and therefore promotes the breaking of the emulsion. When the temperature of the emulsion is about or below the setting point of the oil phase there is very little flow to be expected and the interlocking paraffin crystals that separate have a definite stabilizing effect on the emulsion. The effect of temperature on the rate of breaking of several emulsions can be seen from Graph 1.

With Tests 16, 17 and 18 (Graph 1) the temperature was left as the only variable by standardizing the method and time of mixing equal volumes of the same oil and water samples. Test 19 differed from the other three in that it was shaken up in a different

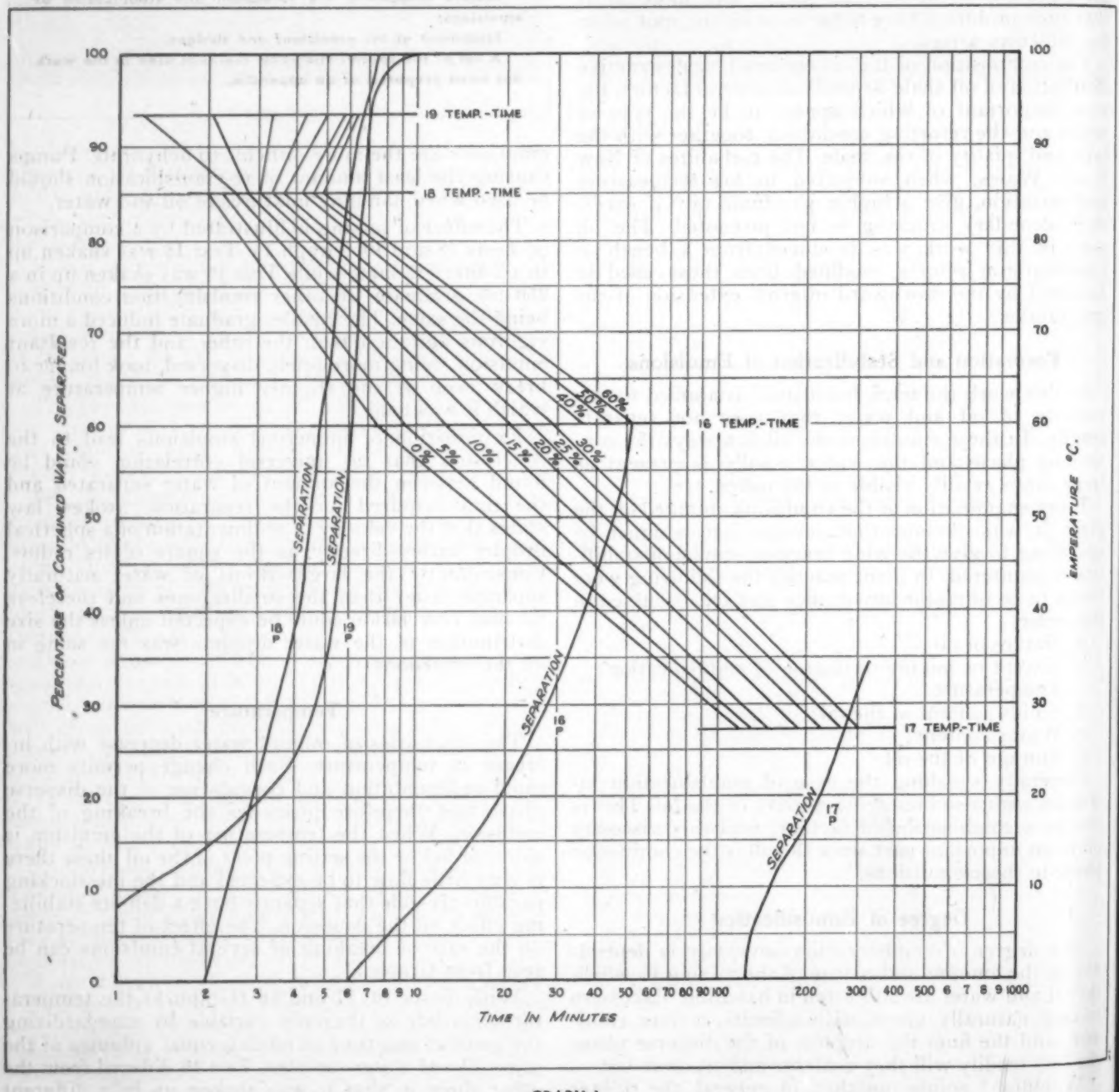
container. As mentioned earlier, this caused the degree of emulsification to differ sufficiently for the test to fail to correlate with the other three.

From Stokes' law the velocity of the falling drops of water, which is directly proportional to their rate of settlement, is inversely proportional to the viscosity of the continuous phase which, in this case, is the oil. Although not exactly so, the viscosity of petroleum products decreases approximately logarithmically with increase in temperature[5, 6] and therefore the approximately logarithmic relationship (Graph I) between the time required for a given percentage of the contained water to separate and the temperature of the emulsion can be attributed to the effect of temperature on the viscosity of the oil.

Solids Content of the Oil

Examination of shale oil during the various stages of its condensation from the retort vapors discloses the presence of varying amounts of a black carbonaceous solid commonly termed "bottom sediment" or BS. This latter term has been used throughout this work to denote this material. Large lumps of coke containing as little as 3.6 percent of ash have been found in the plant emulsions. The low ash content of this coke strongly suggests that it was formed by carbonization of some of the oil in the offtakes from the retorts, and is one pointer to the origin of at least part of the BS. In the presence of water the BS tends to promote a stubborn emulsion with the oil by stabilizing the oil-water interface. These emulsions are difficult to break down and they render the oil unsuitable for refining while they last.

Since the production of oil from shale by retorting methods is essentially a cracking process[2, 7, 8] we can naturally expect the attendant formation of some high-molecular-weight hydrocarbons, some of which could be expected to have characteristics similar to lamp black, gas carbon, etc. Numerous investigators[9, 10, 11, 12, 13, 14] have shown that such materials



GRAPH I

are excellent stabilizers for emulsions of the water-in-oil type.

Observation of the emulsions shows that the separation of the water is retarded, and sometimes even prevented, by oil films that form about the falling drops. With some emulsions these films show visible particles of BS but with others these oil films are clear. This suggests that there are surface-active materials other than BS influencing the oil-water interface.

The BS shows a marked adsorption of phenolphthalein from an alkaline gasoline-water emulsion. This suggests that, by adsorption of high molecular weight materials from the crude oil, the effective BS content of the oil would be increased considerably for emulsion stabilization. Also, by thus increasing their effective surface area, BS particles invisible to the naked eye could well be active in the transparent oil films that prevent the water drops from coalescing.

Among the other surface active materials likely to be present are asphaltic and resinous materials and soaps of naphthenic acids[15, 16] present in the crude oil.

Since the BS is adsorbed at the oil-water interface it was to be expected and has beeen found that after an emulsion has broken partially, the BS content of the oil that has separated (2-5 grams per liter) is considerably less than that of the residual oil in the emulsion, samples of which have been found to contain as much as 42 grams per liter of oil. On standing, especially at elevated temperatures, these emulsions concentrate further with elimination of both oil and water. These emulsion concentrates are called sludges and have been found to contain as much as 15 percent by weight of BS and they generally contain between 50 and 70 percent of water by volume. These sludges are not particularly responsive to the effect of temperature when the BS content is high.

The action of the BS in stabilizing the emulsions and sludges was shown by the following experiment:

Some BS that had been extracted from a sludge was added to a mixture of gasoline and water. It sank through the gasoline to the interface where it remained. When the mixture was shaken up it promoted and stabilized the dispersion of the water in the gasoline phase.

The resultant "grape cluster" formation of large drops of water enclosed in a black film of gasoline and BS persisted for several days. The excess BS settled to the bottom of the gasoline but remained supported by the interfacial films.

A finely ground sample of the coke that had been screened from a plant emulsion stabilized a water-in-gasoline emulsion. A sample of petroleum coke ground to approximately 40 mesh was also found to possess similar activity but it was much less active than only 5 percent of its weight of BS that had been extracted from untreated sludge. These results are in agreement with the observation of Bechold, Dede and Reines[22] that, down to a certain limit, the smaller the particle the greater its activity as an emulsifying agent.

All BS samples contain some ash, some as much as 40 percent. This ash is no different from the ordinary shale ash so it must be attributed to the presence of shale dust drawn off with the gas and oil vapors and then entrained in the oil condensate. Because of the high temperature experienced this shale dust must be completely retorted and therefore should not be greatly different from the carbonaceous shale residue dust other than in ash content.

The effect of the ash content of the BS on its emulsifying ability was shown by the following tests:

1. When 0.45 gms. of shale ash were added to 110 mls. of water and 130 mls. of gasoline most of the solid immediately sank to the bottom of the water. On vigorous shaking some of the solid adhered to the gasoline-wetted walls of the container and an unstable gasoline-in-water emulsion was formed. Some BS containing approximately 40 percent ash was then added in small amounts, each addition being followed by a period of shaking. The degree of emulsification of the gasoline in the water decreased visibly after each addition of the carbonaceous BS until, when approximately 0.2 gms. of the BS had been added, there was a partial phase inversion brought about by the formation of coarse grey films which enclosed part of the aqueous phase. At the same time a very small amount of the gasoline dispersed in the water. The films appeared to be formed by particles of the BS stabilizing a film of gasoline to which particles of the ash also adhered. This suggestion was further borne out by the tendency of the enfilmed water to break from the interface and settle to the bottom of the container. Further addition of BS caused the formation of a typical BS stabilized water-in-gasoline emulsion but the films were much coarser due to the presence of the large amount of added ash.

2. A sample of grey carbonaceous shale-residue dust containing 77.9 percent of ash collected at the interface when shaken with a mixture of gasoline and water. It then had the appearance of a sample of BS that had been coagulated with silicic acid (see later). Closer examination showed that an interfacial film had been formed (about 30 to 40 sq. cm. from approximately 0.2 to 0.3 gm. of the dust). On shaking this film enclosed varying amounts of water depending on the size of the enclosed drops of water.

These tests both suggest that the shale ash content of the solid materials present must be less than about 70 to 80 percent before the carbonaceous material can be active enough to stabilize emulsions.

Water Content

With the emulsions the amount of water present is one obvious factor to be considered, but no relationship could be found between the total water content and the time of separation. From purely geometric considerations Beijerinck[23] estimated that the maximum volume of water that could be dispersed as equal-sized spherical droplets in the oil is 74.04 percent. It is of interest that no emulsions have been encountered that contain quite as much as this (65 to 70 percent of water is not uncommon) the nearest figure being 73.6 percent in a sample of sludge containing 7.5 percent of BS by volume.

The pH of the water present in the plant emulsions has never been found to be less than eight (B.D.H. Universal Indicator). This is due to the presence of ammonia and ammonium salts in the water. The ammonia is present as free ammonia and ammonium carbonate, sulphide, etc., and ranges in amount from about 2 to about 7 pounds of total NH_3 per 1000 gallons of water. The alkalinity to methyl orange usually accounts for at least 50 percent of the total ammonia. As is to be expected the hotter the water the lower is its ammonia content.

Increasing the pH of the aqueous phase of the emulsion, as when determining the tar acid content of the oil by extraction with caustic soda solution, increases both the amount of emulsion formed and the emulsion stability.

Decreasing the pH of the aqueous phase of the emulsion by the addition of a mineral acid was found to increase the rate of breaking.

When crude oil was allowed to rise from a jet through a column of water the addition of 0.5 percent and less of sulphuric acid was found to increase the number and decrease the size of the drops of oil from a given flow. This phenomenon is due to a decrease in the interfacial tension between the two phases and is utilized in the determination of interfacial tensions by means of the Donnan pipette. However, mineral acids were without action on the BS-stabilized water-in-gasoline emulsion.

In a review of the literature, two interesting old patents[24, 25] came to light. With both these patents a mixture of the same chemical nature as the tar bases in the crude shale oil is added to the oil. When made slightly alkaline the oil readily emulsifies with the

water. It is logical, therefore, to assume that the stabilizing action of the higher pH in these emulsions is fundamentally the same as that of the ammonia and alkali in the patents.

The ammonia content of the crude shale oil is of interest in connection with this fact. Ammonia is known to be soluble in mineral oils, but the actual amount present in crude shale oils has not been reported previously. The ammonia content of the oil from different parts of the plant ranged from 0.20 to 0.95 pounds of total NH_3 per 1000 gallons of oil. The lowest ammonia contents were recorded with the oil streams that had had the most contact with water. The ammonia content of the crude oil from the bulk storage tanks has varied little from 0.70 pounds of NH_3 per 1000 gallons of oil.

Storage of the Oil

It has been found that the BS content of the crude oil increases with age, fresh oils generally containing only 1 or 2 grams per liter while oil from the storage tanks generally contains from 6 to 10 grams per liter. This increase in the BS content is now attributed to oxidation and will be discussed further in a later section.

On prolonged storage the crude oil deposits a heavy, fairly rigid sludge on the bottom of the tanks. This deposit contains a high percentage of water in the form of large droplets enclosed in a matrix of oil and BS. In the tanks there has been practically no agitation during the deposition of the sludge and the BS particles have coalesced to form the rigid cell walls enclosing the water droplets which are somewhat lenticular in shape and usually several millimeters in diameter.

One sample, taken from midway between the steam coils of a recently opened tank in order to obtain as undisturbed a sample as possible, contained

	% by weight	% by volume
Water	74.0	73.6
BS	8.9	7.5
Oil	17.1	18.9

The percentages by volume were calculated from the experimental figure of 1.183 for the specific gravity of the BS and on the assumption that the specific gravity of the oil was 0.900 (a sample drained from the dumped sludge had a specific gravity of 0.899 at 60°F.).

In connection with these results it is of interest to note that Berkman and Egloff[19] in quoting Beijerinck[22] point out that, in theoretically possible emulsions having equal-sized spherical droplets of the disperse phase, the critical volume relationship between the disperse phase and the continuous phase is 74.04:25.96.

In the light of this fact the 73.6 percent by volume of water may mean that the sludge deposit "sets" after concentration to the maximum water content geometrically possible in the continuous phase of oil plus BS.

It is of interest that, on mechanical disruption of this sludge, the oil and water that drain off separate cleanly and readily.

In these sludge deposits bands of "pitch" occur and examination of these layers shows that they are not formed suddenly as they are pitted on the bottom, but they finish abruptly on top. This is as would be expected if these layers were deposited from the dry oil after the tank had been standing for some time and then water started to settle out again after another lot of "wet" oil had been run into the tank. By checking the "filling history" of the tanks against the sludge structure on the above assumption an excellent correlation was obtained. Using this theory it has been possible to prophesy, within reasonable limits, both the amount and structure of the sludge to be expected in an unopened tank.

Summary

In summarizing the factors influencing the formation and stabilization of the emulsions we can say that:

1. The lower the specific gravity of the oil the less the tendency to emulsion formation and the lower the stability of any emulsion formed.
2. When the oil and water are mixed together mechanically, emulsification is promoted.
3. Increase in temperature increases the rate of resolution of the emulsions and this effect can be attributed mainly to the decrease in the viscosity of the oil.
4. The presence of carbonaceous solid particles (called BS) in the oil strongly stabilizes the emulsions.
5. The ash content of this BS neutralizes its activity when comprising 75 to 80 percent of the solid by weight.
6. The rate of separation of water from the emulsions depends rather on the drop size of the dispersed water than on the amount present. (Stokes' law).
7. The tendency for emulsion formation and emulsion stability increase and decrease with the pH of the aqueous phase.
8. Reduction of the oil-water interfacial tension increases the rate of resolution of the emulsions.
9. On prolonged storage "wet" crude oil deposits a heavy sludge containing a critical proportion of water and a very high proportion of solids.

Treatment of Emulsions and Sludges

The methods generally employed for the resolution of emulsions and sludges can be divided into the three main classes of physical, mechanical and chemical methods. The borderline between the different classes is far from distinct as they shade into one another, and are often used in conjunction with each other.

Several methods from each of these classes were investigated with view to finding the most efficient method for the resolution of the emulsions and sludges on the plant scale.

Physical Methods

Heat Treatment.

The effect of temperature on the emulsions, which has been discussed earlier, can be put to advantage by maintaining the temperature of the emulsions as high as practicable during their passage through the separators, etc. If the separators are adjusted to deliver only oil and water an emulsion concentrate, containing most of the BS, accumulates until the efficiency of the separator is seriously impaired. However, by pumping away part of the contents of the separator periodically, its efficiency can be maintained quite simply. The emulsion that has been pumped away can be concentrated further by boiling. After boiling for several hours it is allowed to settle and the oil and water that have separated are drained off. By this method the emulsion concentrate can be

further concentrated with elimination of both oil and water until the BS content has increased to such an extent (10 to 15 per cent) that the resultant sludges are no longer affected by boiling.

It seems probable that the effect of boiling the emulsion concentrate may be also partly chemical because of the expulsion of much of the ammonia which assists in the stabilization.

It has frequently been observed that quite obstinate sludges often become covered with a film of clean oil on exposure to the sun. Experimental investigation of the action of radiant heat on the sludges, using several different sources of heat, showed that the effect was due entirely to the increase in the temperature of the surface layer of the sludge. Temperatures as much as 40° F. above the body temperature have been observed in the surface layer. By mechanically removing the separated oil in order to keep the surface of the sludge exposed to the heat rays only the top two to four millimeters of the sludge was resolved. It was found that the BS concentrated in a layer of very heavy sludge which was quite unaffected by the heat. This layer can be compared with the residual sludge obtained after prolonged boiling. The apparent efficiency of solar radiation in breaking the sludges is magnified by the fact that the oil that separates comes from the surface layer and so does not have to pass up through the body of the sludge.

In conclusion it appears that heat treatment of the emulsions causes separation of oil and water finally leaving a heavy sludge concentrate that fails to respond to the further application of this treatment.

Electrical Dehydration.

Many types of electrical equipment and processes for the resolution of oil-field emulsions have been patented and described in the literature.

When subjected to a high-tension electric discharge a loose emulsion broke very readily, one sample separating about fifteen times faster with this treatment than without. However, this method of treatment was apparently quite ineffective when applied to the sludges which are characterized by their high solids (BS) content.

Since others of the methods investigated were capable of treating these sludges this line of attack was not followed up.

Mechanical Methods

Centrifuging.

Laboratory equipment[26] capable of giving a settling force equivalent to approximately 1500 times the force of gravity was found to be unable to give a clean separation in most cases, even after centrifuging for over an hour. Ayres[27] pointed out an interesting fact that the highest centrifugal force causes no greater coalescence than gravity alone; consequently it is obvious that stable emulsions can only be sludged, not broken, by centrifuging.

Filtering.

Discussing the resolution of emulsions by filtration Berkman and Egloff[20] state that "In a filtration process the purpose is to remove a solid substance from a liquid so that one substance passes on, leaving the other behind, deposited on the filter. In the method applied for the dehydration of emulsions the primary object is to separate two liquid phases, both of them passing together through a porous or capillary medium which acts neither as a filter nor as a strainer, but as a device for breaking and coalescing the globular particles of the emulsion."

Experimental work involving the action of various filter media in the resolution of emulsions was carried out, and the results are set out below.

Sand.

Coarse, highly siliceous sand that had been thoroughly washed in running water to remove dust, fine sand, chips, etc., was used in these tests. The washed sand grains were between 1/12-inch and 1/8-inch in diameter.

When filtered through this sand plant emulsions were found to break with varying degrees of completeness, as high as 100 percent resolution being sometimes obtained. The results of these tests can be summarized as follows:

1. The filter holes in the funnel had little, if any, effect in the breaking of the emulsions.
2. All tests using a sand bed were positive.
3. Slow filtration through the sand bed had less effect than rapid filtration.
4. A warm filter bed was more effective than a cold one.
5. A sample of emulsion was less effected by filtration after it had been more thoroughly dispersed by repeated shaking.
6. The rate of filtration decreased with increasing amount of filtrate; the bed finally choking up altogether.
7. The main increase in the resistance was in the surface layer of the filter bed.
8. The efficiency of the filter bed fell off rapidly with use.
9. Examination of the filter bed at the end of the tests showed that each grain of sand was covered with an oil film to which numerous black particles of BS were adhering. This showed that a considerable amount of sludge-forming materials had been removed by the filter bed.

The effect of temperature on the efficiency of the filter bed is in line with the observation of Gilpin and Schneeberger[28] who found that passing a California crude-oil emulsion through fullers earth at 20° C. gave little separation but satisfactory results were obtained at 70° C.

Shale Fines.

Only a negligible resolution was obtained on filtration of the emulsions through a bed of shale fines (plus 1/8-inch minus 1/4-inch). Examination of the filter bed at the end of the tests showed that the upper layers of the shale were quite free from adhering BS particles but there was a little present on the shale at the very bottom of the bed.

Metal Turnings.

Only a negligible resolution was obtained on filtration of the emulsions through a bed of metal turnings. This observation is in direct contrast with the practice adopted by Maschinerien Apparaten Fabriken[29] who obtain resolutions of emulsions by throwing them under pressure upon sharp edges or knives, e. g. steel shavings, and then allowing them to settle.

From the fact that the metal turnings presented both a far greater surface area and number of sharp edges to the emulsion it appears that the action of the sand was specific rather than mechanical. This is supported by the observation that the BS particles accumulated on the sand grains and not on the other filter media. Similar specific action with other filter

media in resolving emulsions has been noted with such materials as fullers earth[28] the adsorptive properties of which are well known.

Chemical Methods

It is now an established fact that, in most cases, three components are essential for the formation of a stable emulsion, viz: two liquids and an emulsifying agent. In relation to this statement Lewis[30, 31] claims that, in the absence of an emulsifying agent, the maximum amount of oil that can be dispersed in water is two percent.

In order to break the emulsion chemically an agent is needed that will destroy the action of the emulsifying agent that is present naturally. In a previous section of this paper the stability of the emulsions and sludges was shown to be affected by a variety of factors, the following being those that should respond readily to the appropriate chemical treatment:

1. The BS present in the oil;
2. The oil-water interfacial tension;
3. The ammonia present in the aqueous liquor.

The investigation outlined below can be conveniently subdivided into three sections in which the line of attack was against each of these factors in turn, viz: respectively a coagulant to entrain and precipitate the BS; wetting agents to decrease the interfacial tension; and acid to neutralize the ammonia, etc.

Silicic Acid.

The active BS is an extremely finely divided carbonaceous material which can be expected to act as an emulsifier in exactly the same manner as does carbon black. Since this is a hydrophobic material a hydrophylic colloid such as silicic acid should be an effective treating agent.[18, 10] The results obtained with the sand filtration work strongly supported the suggestion that the emulsions might respond to a treatment with silicic acid.

In order to obtain an indication of the action of silicic acid on the BS, preliminary work was carried out with BS-stabilized water-in-gasoline emulsions. This established the following facts:

1. Coagulated silicic acid promoted an unstable emulsion of gasoline in water.[10]
2. Coagulated silicic acid broke the BS-stabilized water-in-gasoline emulsion.[10]
3. When the BS particles were somewhat granular (as with the BS from an acid-treated sludge) the effect of the excess silica was readily observed.
4. Uncoagulated silicic acid in a slightly acid solution had no action against a BS-stabilized emulsion.
5. In the concentrations used (up to 20 percent) mineral acids had no action on the BS-stabilized emulsion.
6. When filtered through a fresh bed of sand the BS-stabilized emulsion broke as cleanly as when coagulated silicic acid was added; the BS mostly remaining at the phase interface in an inactive form.
7. Precipitated aluminium hydroxide was also found to be active against the BS but it was by no means as efficient as the silicic acid.

From these results it is obvious that the action of the silicic acid on the BS is the same as that of the sand bed used in the filtration work.

On the laboratory scale quantitative results were obtained with plant emulsions when small amounts of silicic acid were used (0.04 to 0.05 grams of SiO_2 per liter of emulsion), but the results observed were only slightly positive. It was found that after this slight chemical treatment the emulsions responded somewhat to a mechanical treatment such as filtration through cheese cloth or agitation with air. That only slight positive results were observed with these tests can be attributed to insufficient treatment with the silicic acid.

The addition of silicic acid equivalent to 0.5 gram of silica per liter of plant emulsion was quite effective; but the deposition of the coagulated BS on the walls of the containers prevented the quantitative determination of the effect by the usual visual method.

Although this treatment was quite satisfactory with the emulsions it failed with the sludges because of their exceedingly high solids content.

Wetting Agents.

A survey of work on emulsions and emulsifying agents shows that a decrease in interfacial tension usually promotes emulsification. Berkman and Egloff,[17] however, remark that "Tretolite," which is one of the proprietary brands of reagents used to break flow oil emulsions, lowers the interfacial tension. Mighill[32] describes experiments whereby coal-tar emulsions were successfully broken by the employment of wetting agents. He describes a wetting agent as "any agent which, added to an emulsion of water-in-oil, will lower the surface tension at the interface so that the drops will expand and fuse with adjacent drops."

The following commercial wetting agents were examined as de-emulsifying agents:

Agent	Nature
Lissapol C	Sulphated fatty alcohol
Lissapol LS	
Turkey Red Oil PO	Sulphonated castor oil
Perminal WA	Sulphonate of an alkylated aromatic compound.

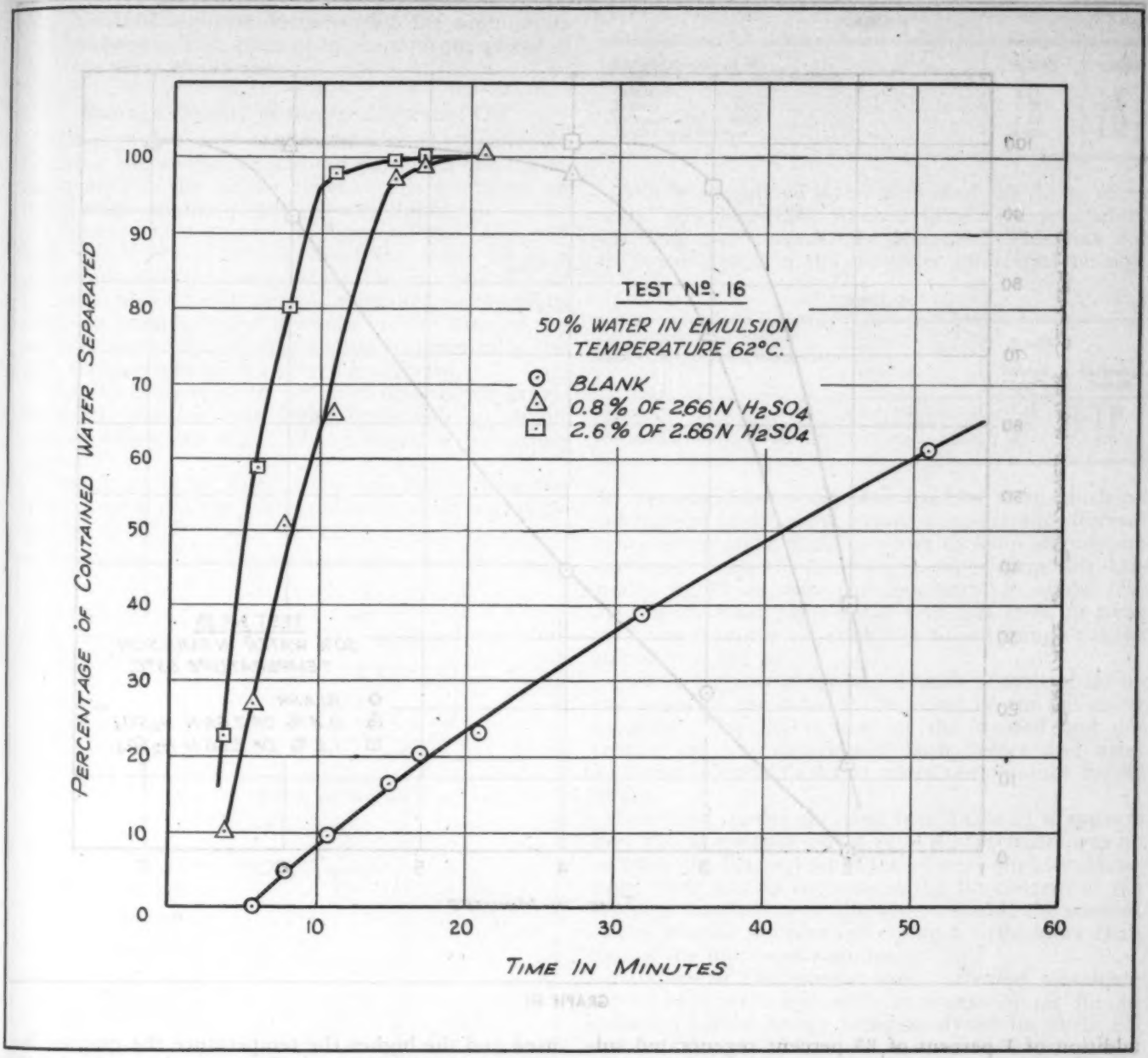
Since the addition of sulphuric acid had been shown to decrease the oil-water interfacial tension it was included in these tests. Pine resin (crude abietic acid) also was used in some of the tests in a concentration four times that used for the other five agents.

The tests were carried out in a hot water bath maintained at 84° ± 2° C.

With artificial emulsions prepared from a heavy crude oil (specific gravity 0.900 at 60° F.) and bore water the de-emulsifying activities of these various agents and sulphuric acid when used in concentrations ranging from 0.025 to 0.125 percent were found to be in the following order: Sulphuric Acid > Lissapol C > Turkey Red Oil PO = Perminal WA > Blank = Resin > Lissapol LS.

As a check on the effect of the materials such as the ammonium carbonate present in the aqueous phase of the plant emulsions a further series of tests was carried out using an artificial emulsion prepared from a sample of crude oil (specific gravity 0.886 at 60° F.) and water previously separated from plant emulsions. The results of these tests placed the agents in the following different order of activity: Sulphuric Acid > Resin > Turkey Red Oil PO > Perminal WA = Blank = Lissapol C = Lissapol LS.

These results showed that the materials present in the aqueous liquors from the plant materially affect the stability of the emulsions and the activity of the various agents. The improved efficiency of the resin was undoubtedly due to the formation of a resin soap



GRAPH II

with the ammonia and this would have "wetting" properties.

In equal concentrations by weight sulphuric acid was the most efficient of the materials tested. Under these circumstances it was considered to be not worthwhile attempting to resolve the stubborn sludges by means of proprietary wetting agents.

Acid

Action of the Acid.

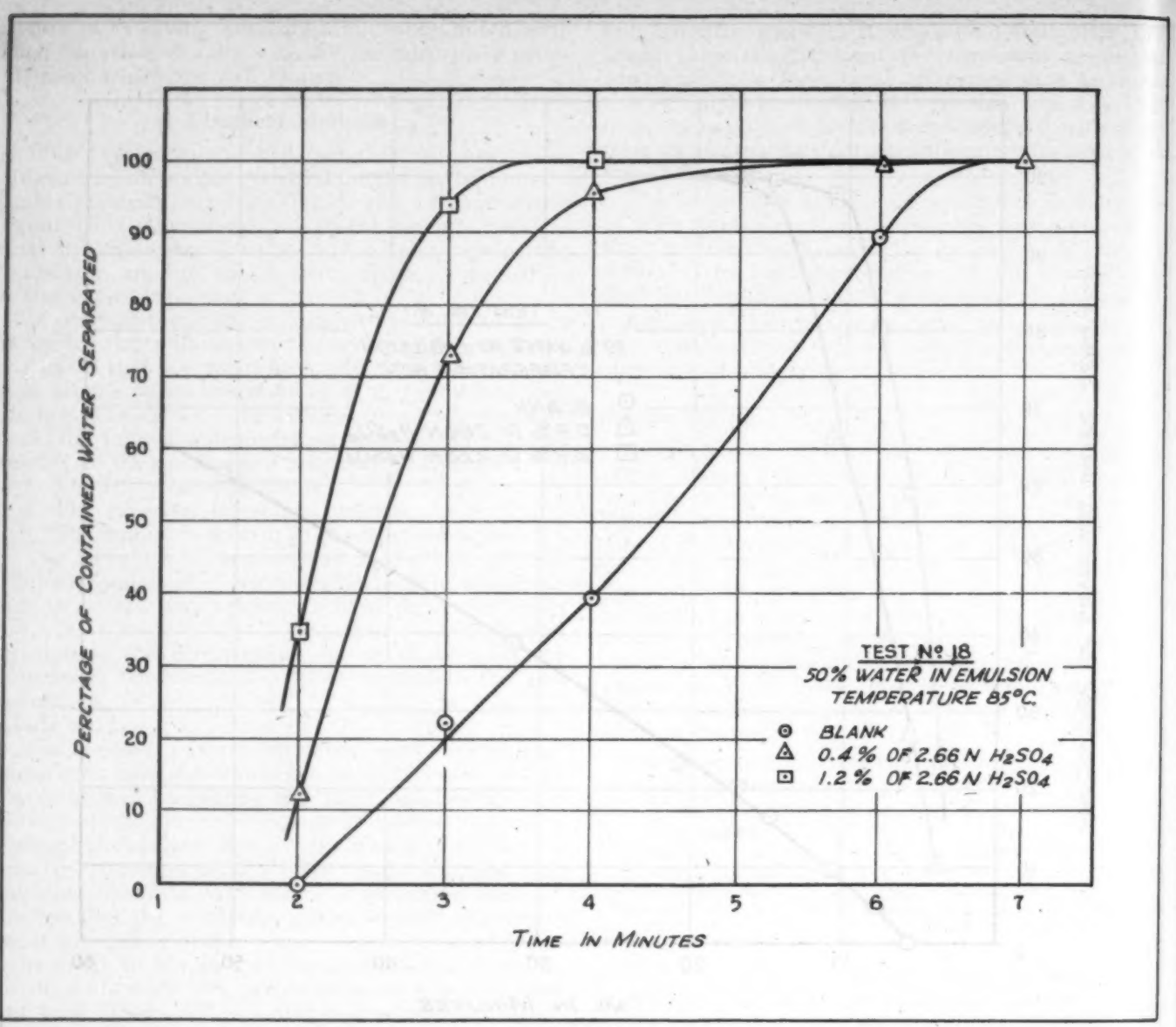
With these shale-oil emulsions acids have been shown to be active resolving agents by decreasing the oil-water interfacial tension and by neutralizing the ammonia, etc., present in the aqueous phase.

Hydrochloric acid and sulphuric acid were both quite efficient but the former was not considered as it is the dearer reagent and residual traces possibly left in the oil would give rise to corrosive conditions in the refinery equipment more readily than would sulphuric acid. Both sulphuric acid obtained by hydrolysis of the refinery acid sludge and containing an appreciable amount of tar bases, and acid sodium sulphate were tested and both gave results which did not differentiate them from the pure acid. Examples of the quantitative effect of the action of the acid are given in Graphs II and III.

A few other investigators have used acids to resolve emulsions but this practice is by no means common because, when applicable, possible corrosion of equipment, etc., is a powerful argument against their use. However, tar bases are very active acid-corrosion inhibitors and an appreciable amount can be taken up from the oil by the acid; with this oil as much as 0.07 gram equivalents per liter have been found in the acid after treatment. The negligible corrosion experienced even after prolonged use of mild-steel tanks for the treatment is attributed to this cause.

Sherrick[33] found that acids were effective in resolving an emulsion from a Texas field. Their efficiency was proportional to the hydrogen ion concentration, this being the effective agent by neutralizing the negative charge carried by the water globules.

Bukh[34,35] resolved Kala crude oil emulsions by the



GRAPH III

addition of 1 percent of 25 percent regenerated sulphuric acid at 50° C. The contacting period in the acid treating equipment was seven to eight seconds. Twenty to 30 percent of sea water subsequently was used to wash away the acid. He also resolved Baku crude oil emulsions[36] by treatment with sulphuric acid followed by neutralization with caustic soda.

Kligerman[37] reports that the heavily emulsified Kala crude oil in Tsaritstan, used as a boiler fuel, had been demulsified by admitting 0.5 percent of sulphuric acid and agitating with steam and air. The acidified water collected on the bottom of the storage tank and was constantly replaced by fresh water.

Bottars[21] also used acids for the disintegration of emulsions but he used as much as 5 percent of sulphuric acid to resolve oil-in-water emulsions containing solid substances.

It is of interest to note that, after contact with an excess of concentrated sulphuric acid, the crude shale oil exhibits a very strong blue fluorescence in place of the usual dark green fluorescence.

Experiment showed that the treatment of the emulsions with dilute mineral acids increased the amount of BS present quite considerably. All emulsions tested showed the efficacy of the acid treatment and all showed an increased solids content; the more acid used and the higher the temperature the greater the amount of solids formed. This was obviously due to the acid polymerizing part of the more unstable constituents of the oil.

In order to determine the effect of the acid treatment on the oil 10 milliliters of 2.58N sulphuric acid, 100 milliliters of distilled water and 200 milliliters of crude oil were stirred together in a beaker and heated. Some gummy sludge was formed but this redissolved on further heating. The heating was continued until the water began to boil. Only about one half a milliliter of a pitchy solid was formed. Examination of the treated and untreated oils showed that it can be safely considered that the acid treatment had no deleterious effect on the oil as a raw material for the manufacture of gasoline by the process of thermal cracking.

In summarizing the action of sulphuric acid, we can say that its superior action over all the other agents investigated in connection with crude shale oil emulsions can be attributed to its threefold action in:

1. Decreasing the oil-water interfacial tension.
2. Coagulating the surface active BS by entrainment in the trace of polymerization product formed.

3. Neutralizing and decomposing the ammonium carbonate, etc., present in the aqueous phase of the plant emulsions.

Storage Quality of the Acid Treated Oil

Although the acid treatment proved effective in breaking the emulsions and did not affect the cracking quality of the oil the effect of this treatment on the storage quality of the oil was unknown.

The apparatus shown in Figure 1 was designed with the object of acid washing the crude oil at a somewhat elevated temperature (approx. 90° C.) in the same manner as it would be washed on the plant scale. In passing down the tube to the base of the washing tower the oil was heated to practically the bath temperature before entering the acid.

The BS content of the oil was determined gravimetrically since it was found impossible to obtain reliable values by means of the standard centrifuge method.[26]

The oil used for these tests was taken from the final crude oil storage tanks and had a specific gravity of 0.889 at 60° F.

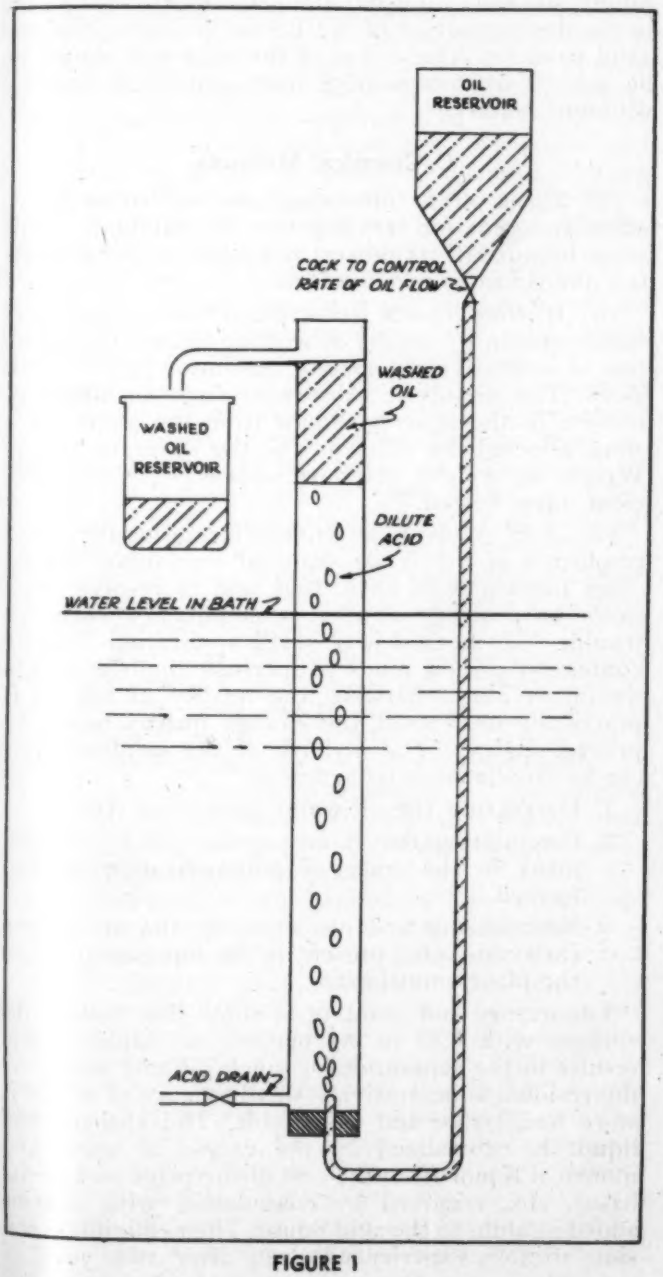


FIGURE 1

TABLE 1

Initial acid strength (H_2SO_4)	0.236N	0.305N
Results (BS contents in grams per liter):		
Untreated	2.11	1.50
Treated	2.28	1.53
Untreated after 48 hours	2.53	2.45
Treated after 48 hours	3.05	2.70

When unacidified water was used the drops of oil were very large but when a little acid was added the drop size immediately decreased. This was due to the decrease in the oil-water interfacial tension.

TABLE 2

Initial strength of acid (H_2SO_4)	0.148N	....
Results (BS contents in grams per liter):	Treated Sample	Untreated Sample
At time of test	1.45	1.45
After standing open for 234 days	3.3	5.2
After standing sealed for 234 days	2.1	1.9

If the unacidified water was used to wash much oil subsequent acidification caused considerable effervescence, suggesting that the water took up ammonium carbonate from the oil. In any experiment this naturally would decrease the concentration of the free acid in the wash liquor. The acid also took up some tar bases from the oil, changing color through orange to red as it did so.

After every run there was a small deposit of tar on the walls of the tube at the level of the oil-water interface. The BS content of the treated and untreated oil was determined both before and after standing in open flasks at room temperature for 48 hours.

From the results obtained (see Table 1) it appears that the immediate effect of the acid wash was to increase the BS content of the oil very slightly. However, there was an increase in the BS content of the samples that had been allowed to stand; the content of the treated samples increasing a little more than that of the untreated samples.

Samples of the treated and untreated oils were stored both with and without access of air for an extended period before being analyzed for their BS content. The sealed samples were stored in stoppered flasks that were filled completely.

With the results obtained (see Table 2) it must be noted that, in this case, the immediate BS content of the oil was not affected by the acid. This may well be due to the lower concentration of acid used.

The BS content of the samples that stood open to the air for about eight months increased considerably, but with the acid-washed sample this increase was approximately only 50 percent of the increase of the unwashed sample. This can be attributed to the acid causing the polymerization of some of the BS-forming materials and their subsequent deposition at the oil-water interface. However, corresponding that had been sealed, but were not perfectly airtight, also showed a BS increase, but to a very much smaller extent. This suggests that the increase in the BS content of the crude oil on standing is almost, even if not entirely, due to atmospheric oxidation.

Sludge Treatment

From these results it can be said that, by removing some of the BS and sludge-forming materials a mild acid wash improves the storage stability of the crude shale oil.

Heating the emulsion concentrate or sludge with

a little sulphuric acid was found to be an efficient method for the recovery part of the oil and, on the laboratory scale, the oil recovery was far greater when acid was used than when heat alone was supplied.

Heating a 30-gallon sample of a heavy sludge (2.3 percent BS) with 3 pounds of sulphuric acid resulted in the recovery of 67 percent of the oil present. The residual sludge in the drum after draining had a solids content several times that of the original sludge and it contained 37 percent of oil. The ash content of the BS from the treated sludge was about half that of the BS from the original sludge. This observation is in agreement with the very mild polymerizing action of the sulphuric acid that has been remarked on previously. The recovered oil appeared to be no different from the usual crude oil but for a slight loss of the lower-boiling fraction.

After the treatment of the sludges with sulphuric acid had been proved to work on a small scale several full-scale tests were carried out on the plant, using open tanks holding 4000 to 10,000 gallons of sludge. These tests showed that, when the sludge concentrate failed to respond to further boiling, the addition of as little at 0.1 percent by volume of 95 percent sulphuric acid had a marked concentrating effect, and that 0.25 to 0.4 percent of acid was able to concentrate the sludge sufficiently to facilitate ready handling when cleaning the tanks after treatment. This factor alone is of sufficient value to warrant the treatment apart from the value of the oil recovered and the considerable reduction in the volume of the residual sludge that has to be handled and dumped. The composition of this residual sludge is comparatively constant, the acid concentration from 0.25 percent up having no apparent effect on the proportions of the various constituents which are usually within about 1 percent of 48 percent of water and 25 percent of solids.

It was also found that the method employed in adding the acid was most important, thorough mixing being absolutely essential as otherwise portions of the sludge, especially in the corners of the tank, could readily escape treatment because of its semi-solid nature.

Disposal of the Waste Acid Liquor

The waste aqueous liquor from the acid treatment of the sludge usually contains up to about 1 percent of total sulphuric acid, 25 percent or so of which is in combination with tar bases from the oil. It also contains an appreciable amount of iron sulphates present as impurities in the original acid. The negligible corrosion experienced in handling this liquid in mild-steel tanks, even though the usual treatment involves boiling, can be attributed to the presence of the tar bases which, as a class, are known to exhibit strong acid-corrosion inhibiting powers. The waste liquor from the rest of the plant is ammoniacal and contains traces of sulphides, etc. When draining the acid liquor the relative flows of the two effluents are such that the mixture has a pH about 8. Under these conditions the tar bases and iron oxides and sulphides that are precipitated form an extremely fine, almost colloidal, suspension that requires several hours to separate out. The addition of alum to the sludge at the time of treatment was found to improve the flocculation characteristics of this troublesome precipitate, the effluent neutralized waste liquor then clarifying much more rapidly.

Summary

The different methods examined for the resolution of the emulsions and sludges are summarized below:

A. Physical Methods

(a) *Heat Treatment.* Maintaining the emulsions as hot as possible speeds up their resolution. The emulsion concentrates can be readily concentrated further by boiling; oil and water separating until only a heavy sludge is left. Experiments with radiant heat showed no advantage over the use of direct heat.

(b) *Electrical Dehydration.* Although electrical methods showed promise with the emulsions, the sludges did not respond.

B. Mechanical Methods

(a) *Centrifuging.* This method is fairly successful only with the emulsions and is of no use with the sludges. The solids deposited from the oil are a handicap to the application of this method.

(b) *Filtering.* Initial excellent resolution was obtained on filtering the emulsions through course, highly siliceous sand but the bed fouled rapidly due to the decomposition of the BS on the surface of the sand particles. The action of the sand was shown to be specific by comparative tests with filter beds of different materials.

C. Chemical Methods

(a) *Silicic Acid.* Silicic acid was shown to be an effective agent for treating the BS-stabilized emulsions because of its power to coagulate and precipitate the BS in an inactive form.

(b) *Wetting Agents.* Reduction of the oil-water interfacial tension by means of wetting agents was effective in increasing the rate of resolution of the emulsions. The dissolved substances such as ammonia, present in the aqueous liquor from the plant emulsions affected the efficiency of the different agents. Weight for weight, sulphuric acid was the most efficient agent tested.

(c) *Acid.* Acids are effective in increasing the rate of resolution of the crude shale-oil emulsions. Several other investigators have used acid to resolve emulsions but, owing to the possibility of corrosion trouble, this method is of small application. The BS content of the oil tends to increase slightly on acid treatment but, otherwise, the quality of the oil is practically unaffected, the storage quality being improved slightly. The activity of the sulphuric acid can be attributed to its action in:

1. Decreasing the oil-water interfacial tension.
2. Coagulating the surface active BS by entrainment in the trace of polymerization product formed.
3. Neutralizing and decomposing the ammonium carbonate, etc., present in the aqueous phase of the plant emulsions.

Laboratory and plant tests show that boiling the sludges with 0.25 to 0.4 percent of sulphuric acid results in the separation of much oil and water and the residual comparatively small amount of sludge is more handleable and disposable. The effluent acid liquor is neutralized by the excess of waste ammoniacal liquor from the rest of the plant and the tar bases, etc., removed by coagulation with alumina added as alum to the acid liquor. The negligible corrosion trouble experienced even after two years of

treatment is attributed to the presence of dissolved tar bases in the dilute acid liquor.

Acknowledgment

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APPENDIX
Special Analytical Methods

1. *Determination of the Rate of Resolution of the Emulsions.*

Two hundred and fifty milliliters of the test emulsion were poured uniformly into each of several 250-ml. graduated cylinders and any reagent added from a pipette. Each cylinder was then inverted several times to insure thorough mixing with the reagent. The cylinder without any reagent was subjected to the same treatment. The cylinders were then all placed in a bath of hot water maintained within 1° C. of the temperature of the test. The time was observed from the completion of this operation. When a reading was taken the cylinder was lifted from the bath and rotated sharply several times to break the adhesion of the coarse emulsion films to the glass. Although the amount of handling did not affect the rate of true separation it was kept constant for all samples and readings throughout each test. With the hotter samples, this manipulation was unnecessary but at the lower temperatures the oil films tended to adhere to the glass so strongly that the separation could not be observed without it.

2. *Determination of the BS content of the oils.*

The simple centrifuge method[26] was examined and was found to give quite erratic results, so the determinations were carried out gravimetrically.

A non-aromatic solvent such as petroleum ether was used to dilute the oil since the BS is largely soluble in benzene. A measured volume of the oil was diluted with one to two times its volume of the solvent and filtered through a filter paper that previously had been washed with the solvent, dried and weighed to 0.01 gram. The precipitate tended to clog the filter so suction could not be used. Quicker filtering was obtained if the precipitate were frequently washed to the bottom of the filter by a jet of the solvent. The filter and precipitate were then washed until completely free from oil and dried in the air oven with the door ajar until free from the odor of the solvent. They were then weighed to 0.01 grams and the BS expressed as grams per litre of oil.

Since filter paper is hygroscopic, it was weighed immediately after being removed from the air oven. This was easily done, as the paper cooled very rapidly.

3. *Examination of Sludges.*

One hundred to 200 milliliters of sludge were weighed into a 500 or 1000 millileter bolthead flask to 0.1 gram, and 100 to 200 milliliters of heavy non-aromatic gasoline or lighting kerosine added. The water was distilled off, using a modified Dean and Stark apparatus. When all the water had distilled off, the contents of the flask were filtered through a 15 cm. No. 1 Whatman filter paper that had previously been dried in the air over for a short time, and then weighed to 0.01 gram. The residual solids were rinsed from the flask with a light gasoline (*not* benzene), and the precipitated BS washed until the filtrate was colorless. The filter paper and the BS were dried in the air oven with the door ajar until free from the odor of gasoline before weighing. The oil content was found by difference.

4. *Determination of the Specific Gravity of the BS.*

The carbonaceous BS samples were not at all readily wetted by water so another liquid had to be used which would efficiently "wet" the powder before SG determinations could be carried out by the density-bottle method. Gasoline was found to be such a suitable liquid. It was found that the powder was much more readily wetted if added to some gasoline in the bottle rather than the gasoline added to the powder. A heavy gasoline or kerosine was used to reduce evaporation changes during the determinations.

5. *Determination of Ammonia in Crude Oil.*

One hundred milliliters of the oil were measured into a flask of 500 milliliters capacity or larger, together with 100 milliliters of ammonia-free distilled water and 5 milliliters of 30 percent caustic soda solution. The addition of 5 milliliters of amyl alcohol was made to promote more even boiling with less bumping. The mixture was then distilled through a splash-head into a known amount of standard acid, about 20 milliliters of decinormal acid being sufficient. After all the ammonia had distilled off the acid was back-titrated with standard caustic soda using methyl orange indicator.

If insufficient water had been added severe bumping would occur while without the amyl alcohol severe priming and foaming was likely to ruin the determination.

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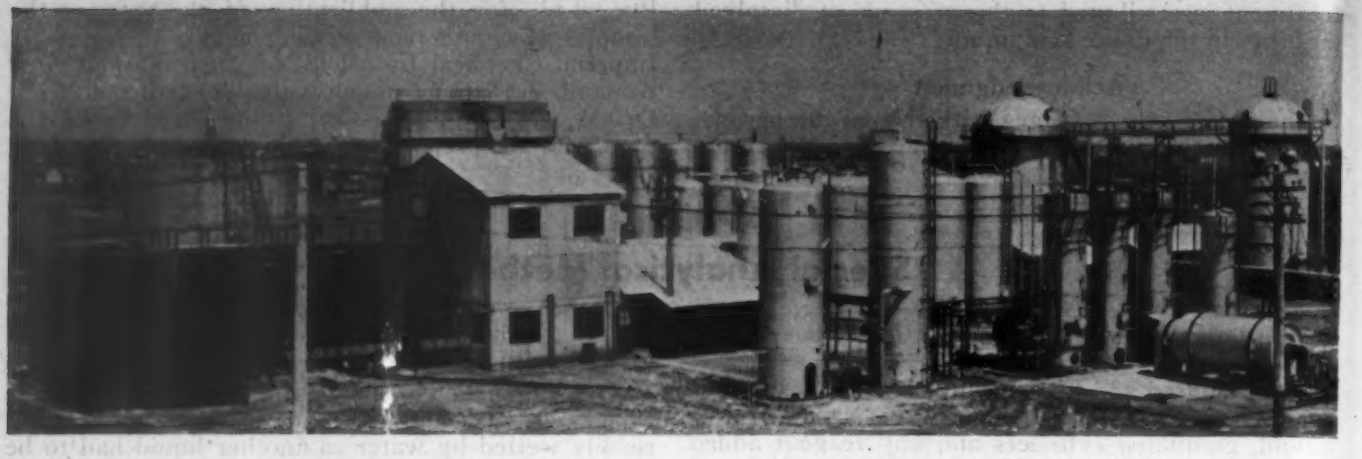
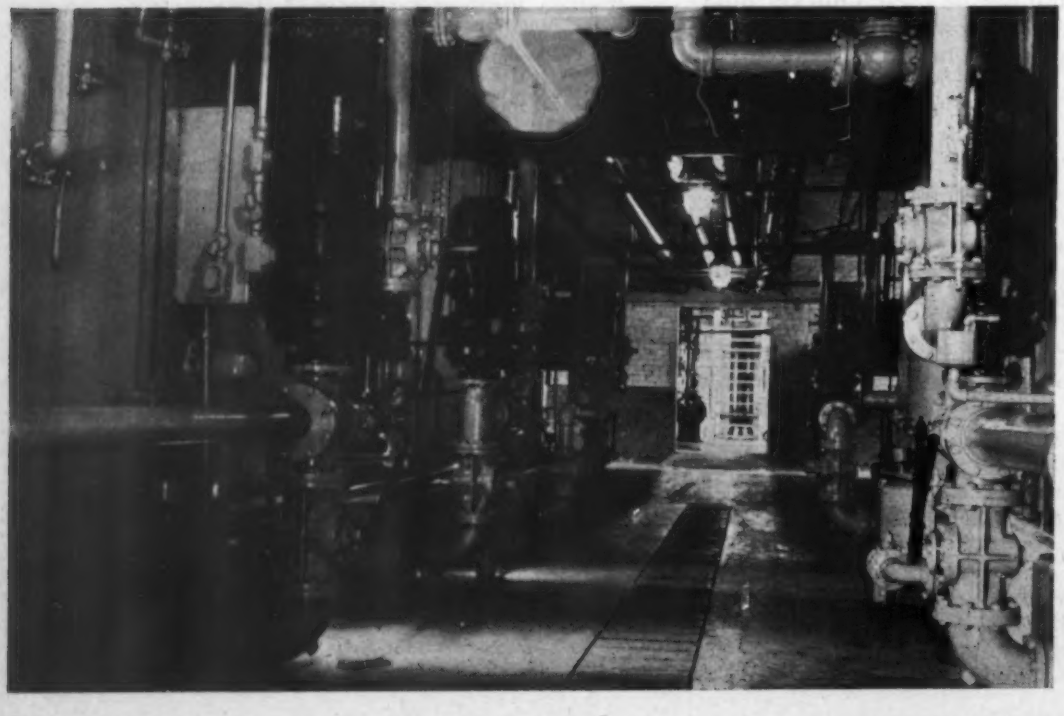


Skelly Blends Gasoline Before Sweetening

IN THE treating process of Skelly Oil Company, Eldorado, Kansas, the desired blends for balanced motor fuel are determined prior to the sweetening process. Thus two grades of straight-run gasoline, two cuts of cracked distillates, the product from vapor recovery and natural gasoline become a common stream on the liquid copper side of the treating unit.

The treating plant is a combination of caustic washing for hydrogen sulfide removal, followed by sweetening. Chemical treating is an individual process for each commodity, which goes to its respective stock tank. In turn pumps and control equipment are set for delivering required proportions of the several materials, which then go to the copper sweetening equipment correctly blended for a balanced motor fuel. Although the two treating processes operate independently, they are grouped in and around one building and have common control. This grouping plus the blending arrangement reduce pumping and handling requirements in contrast with the practice of blending after final treating.

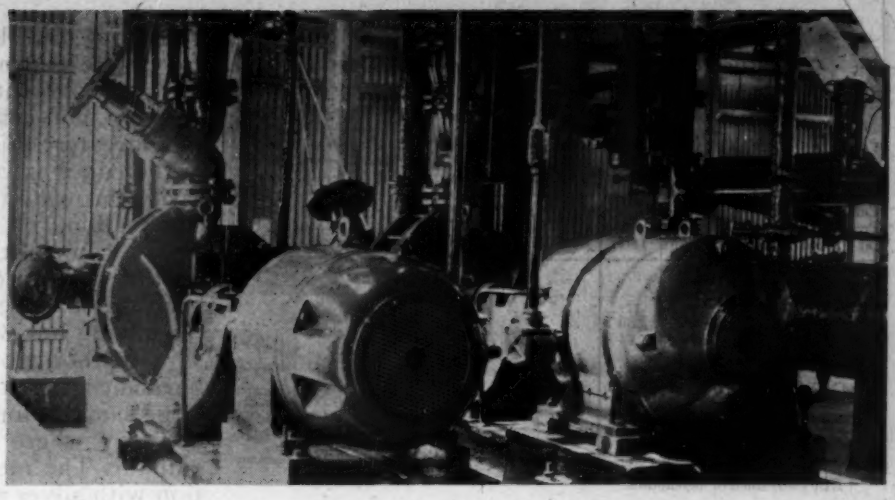
Caustic contact is provided in two rows of vertical vessels which are housed for a part of their length. The arrangement allows an alley between the tank batteries. Material for caustic contact is delivered to each vessel through a motor-driven, close-coupled centrifugal pump. This pump and its drive are mounted vertically to a bracket welded to the side of the vessel. This installation requires less space and allows use of short suction and discharge lines. This



Alley-way between vertical contact tanks in Skelly Oil Company's treating plant at Eldorado, Kansas. Mixing pumps are vertically mounted on brackets welded to the side of the vessel. Building housing this equipment is readily seen in the general view of the treating plant shown at top of this page.

pump assures adequate contact between chemical and distillate, which is delivered from working storage by commodity pumps.

Suction to these pumps is so manifolded that both product and chemical can be controlled manually at the vessel. The discharge is near the middle of the tank. Treated gasoline leaves each vessel at the top and passes into a succeeding tank for settling. From the settler it flows at process pressure to vapor-proof storage where it is available for the combination blending and copper sweetening process.



Two motor-driven pumps operate in series to mix chemicals with products in copper treating plant.

When a motor fuel is to be blended, calculations are made to determine proper amounts of each product essential to a gasoline of the required gravity, distillation range and octane value. Control instruments then are set to bring these proportions into a common stream, which goes into the copper sweetening unit. The copper treating plant consists of two units, which may operate simultaneously but there is no provision for combining streams after treating.

Pumps for the several liquids of each blend are in the open space of the treating room. Suction is so manifolded that any pump can be shifted from one tank to another. The discharge of each pump is so arranged that it can work with either section of the treating plant.

Contact of the correctly proportioned gasoline stream is through corrosive-resistant pumps. The treating agent is delivered through plastic piping. Thus from the several distillate streams and the one treating-agent pump, the complete blend of motor fuel comes in contact with the treating agent.

Each side of the sweentening plant consists of three wooden tanks. Two tanks of each battery are connected to suction on the contact pump, while the third tank is for regeneration of the treating agent.

After contact with the liquid copper stream in the treating pump the combination of motor fuel and treating agent passes overhead to a glass-lined breaker tank. Each side of this part of the treating process has its individual breaker tank. The breaker tank is elevated, so both gasoline and treating fluid leave by gravity after separation. Level controls at each end of these tanks permit gasoline to leave at the top of the shell, while the chemical flows from the lower side. Since no emulsion is formed, separation is rapid in this tank.

The treated motor fuel flows by gravity to storage after pass through a sodium sulfide wash, a precaution against carry over of copper from the breaker tank.

From the breaker tank the treating agent, then cuprous chloride, goes to the aerator vessel where it is converted to cupric chloride and is ready for introduction in the system as a treating agent.

The aerator tank is equipped with an air header so compressed air can be introduced into the liquid near the tank bottom. The air passes through diffusion discs to assure maximum contact between air and liquid. Air is delivered by a motor-driven compressor at 15 pounds discharge pressure.

Determination of Mercaptan Sulphur In Calorimetric Bomb

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ACCORDING to Griffin[1] the combustion of sulphur-containing oils in the calorimetric bomb gives results which are to low, which is said to be due to the fact that sulpho-acids which form to some extent yield water-soluble barium salts, and therefore escape determination. According to his views, this is especially pronounced in the case of mercaptans; he gives no further conditions as to the combustion technique, nor is any mention made concerning oxygen pressures used in the combustion. He examined the filtrate for sulphur derivatives, since in the exit gases no sulphur dioxide could be detected. He was able to determine and account for the missing sulphur to a great extent by heating under reflux for several hours with concentrated hydrochloric acid, concentrating finally and heating to dryness.

It should be mentioned that this secondary treatment was always found necessary, even with the combustion of pure sulphur.

In contrast to the above Weisselberg[2] found he could account for 98-99 percent of the sulphur in the combustion of a gasoil containing sulphur in solution, as well as for oils containing sulphur derivatives, to-

* Translated from Brenn- Chemie 20 (1939) 348.

TABLE 1

Combustion of Ethyl Mercaptan at Various Pressures

Combustion Press. Atm. of Oxygen	PERCENT SULPHUR FOUND FOR A CONTENT OF								
	3.43% or 3.35% Mercap.—S or 6.5% Ethyl Mercap. With			5.17% S or 5.19% Mercap.—S or 9.9% Ethyl Mercap. With			45.6% S or 45% Mercap.—S or 87% Ethyl Mercap. With		
	Bomb	Further Treatment	Total	Bomb	Further Treatment	Total	Bomb	Further Treatment	Total
10	...*	...	...	...	...	...	36.0*	...	.....
15	...*	...	...	...*	...	...	.....	...	.....
20	.....	.....	.....	.....	...	...	38.0*	...	.....
25	3.10	0.2	3.30	...	...	...	.....	...	.....
	3.44	...	3.44	...	...	...	.....	...	.....
	3.27	0.12	3.39	...	...	...	.....	...	.....
30	3.43	...	3.43	5.13	trace	5.13	40.3	4.1	44.4
	3.42	...	3.42	5.13	trace	5.13	.....	...	.....
35	3.43	...	3.43	5.17	...	5.17	45.0	0.22	45.22
	...	...	...	5.18	...	5.18	41.7	2.17	43.87
	...	...	...	...	...	...	40.9	3.21	44.11

* Exit gases smell of mercaptans.

gether with benzine containing thiophenol in added form. His method was to conduct the combustion at a pressure of 35 atmospheres, and oxidized with bromine water after allowing the aqueous solution to stand in cold water 10 minutes. In determining pure sulphur he added hydrocarbon material since he lays stress on the formation of water during combustion. Due to the abundant formation of water the sulphur-oxides are rapidly precipitated, as mentioned also by other workers in this field[3]. He does not agree with Griffin in his theory concerning his explanation of the formation of sulpho-acids, especially since he could determine very accurately the sulphur contained in mixes of thiophenol which were as high as 8-21 percent in sulphur content.

Graefe[4] carried out considerable work and does not agree with the above views concerning the formation of sulpho-acids under the described conditions. According to him Griffin apparently lost his sulphur in the exit gases. If this were the case though, then Griffin could not have found some sulphur in the filtrate.

Our own investigations have shown that in dealing with hydrocarbons containing mercaptan-sulphur, we could obtain the correct values without too stringent precautions by ordinary bomb combustion methods.

We employed a vanadium steel (V-A) bomb, containing a metal cup of 20/40 chrome-nickel steel, which is exceedingly resistant to high temperatures. (V_2 A in this case, for example, is not especially suited, since at high temperatures it loses its austenitic structure). The chrome-nickel cup has lasted through several hundred determinations. The steel becomes coated with a very thin oxide coat, though this does not cause any sulphur to combine with it; perhaps the cup does not get hot enough to form metallic sulphides. The cup also preserves its shape very well in contrast, to say, platinum—so that we found it well suited for this work.

For the combustion we employ a small bulb filled with the unknown oil, and stoppered with a small cork; the weight before and after filling this bulb equals the weight of the oil used so that there is no loss of light or volatile portions of the oil. The bulb is laid in the metal cup and the ignition wire is fastened tightly in a slit in the cork. Just before closing the bomb the point of the bulb is broken off and the point is also laid in the cup. One obtains in this manner a rapid and complete combustion. If one employs the customery well known thin-walled bulbs there is great danger that the oxygen under pressure will collapse them violently and spatter some of the oil out of the cup, which results in some of the oil not being burned up. If, likewise, one adds a small amount of lye to the cup a procedure quite advantageous for the quick absorption of the sulphur-oxides, the possibility of non-combustion of some of the sample is even greater; this is because when the bulb splinters in the cup it is very likely that part of the sample is easily thrown out in the lye, and there again escapes combustion.

As a comparative test procedure we used the combustion method (in a quartz tube) of Grote and Krekeler[5] as a check—a method which is quite time-consuming but which always yields excellent results. This method alows all the sulphur to be completely burned and it has also an advantage of employing large samples for the determination, making for great accuracy where samples contain minute amounts of sulphur. The mercaptans were determined by nitration with silver nitrate[6] after adding methanol[7].

Earlier determinations showed us the effect of the pressure and water-vapor. One should not work at too low a pressure; 15-25 atm. as often recommended will not suffice.

For test determinations we used ethyl mercaptan in various dilutions with sulphur-free naptha; care was taken to prevent any previous oxidation so that sulphur was known to be all in the mercaptan form.

We burned the oil samples under various initial oxygen pressures in order to determine the effect of the combustion pressure; one gram samples were used for sulphur-poor oils, and 0.4 gm samples for high-sulphur oils. Whenever the odor indicated there were no unspent mercaptans present, and yet not obtaining the theoretical percentage, then the filtrate was further worked up according to Griffins' described method.

The results are shown in Table 1. The results appear to be dependent on pressure and on the mercaptan concentration. One obtains trustworthy results with a concentration of 3 percent mercaptan sulphur at 30 atmospheres with 5 percent concentration one is forced to use 35 atmosphere pressure. With high mercaptan content this pressure seems inadequate; the Griffin treatment then leaves much to be desired. Aside from the cumbersome procedure theoretical values were not obtained in any case, as one would have expected from the described procedure of Griffin.

The fact that Weisselberg obtained exact results with thiophenol is not astonishing since the lower aliphatic mercaptans are more stable than thiophenol. and also very volatile; his determinations contained 21 percent sulphur. One is uncertain concerning Griffin's results about aliphatic mercaptans; it does not seem at all clear that he obtained as in the case of elementary sulphur values which were to low—finding this sulphur in the filtrate from the barium sulphate precipitation.

Summary

Low weight aliphatic mercaptans can only be accurately determined in the calorimetric bomb by employing initial oxygen pressures of at least 35 atmospheres; the mercaptans must be highly diluted. Using concentrated mercaptans the method of Grote and Krekeler (combustion in quartz tubes) is also still an excellent method.

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X-Ray Diffraction

ARTICLE 3

Application of X-Ray Diffraction

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AS HAS been indicated previously, the science of x-ray diffraction is essentially a structure analysis, in which the arrangement of the atoms within the material and their relationship to each other provide the analytical information.

The information desired, however, will not be of the same type in each case, and will govern the method of analysis employed.

For example, the following types of x-ray analysis may be employed, each of which enables different data to be ascertained.

1. Simple chemical identification.
2. Phase identification, qualitative and quantitative, with two or more identities present.
3. Determination of lattice parameters.
4. Quantitative determination of solid or mutual solubility.
5. Average particle size evaluation.
6. Particle size distribution studies.
7. Orientation in solid materials and correlation with mechanical and other data.
8. Molecular-weight determination (especially in the case of high-molecular-weight materials such as proteins).
9. Stress analysis in metals.
10. Grain-size determination.
11. Structure determination.
12. Order—disorder phenomena studies.
13. Atomic distribution in amorphous substances such as glasses.

Simple chemical identification can be undertaken using x-ray diffraction methods by employing either a direct comparison method or by computing the corresponding spacings of the pattern and searching for the substance in the Hanawalt card index system.

In a number of cases difficulty will be experienced in identification, due mainly to the unusual nature of the material, which may not have been previously identified or reported in the literature.

This is apt to occur when the unknown has been produced under unusual conditions, such as the scale found in high-pressure steam boilers, or the deposit found in heat exchangers in cracking plants.

This method, as was previously explained, is primarily identification by crystalline structure rather than element identification.

For example, in studying SiO_2 the material can be found in several forms, such as mineral quartz, cristobalite, tridymite or vitreous silica, each modification giving a different type of pattern that is unique.

In the various cracking and hydroforming processes where the nature of the catalyst is extremely important, the catalyst form can be readily identified before and after use. For instance, in the hydroforming process, gamma alumina is used and when heated too highly forms corundum.[1] The change can be followed on a time-temperature basis, and formation of the unwanted corundum prevented.

Some preliminary work has been done on identification of various asphalts and have been reported in the literature.[2]

The importance of an accurate mineralogical analysis in petroleum exploration is becoming more and more apparent as evidenced by the interest shown in the field. The x-ray method can separate out the major components quantitatively which may contain such minerals as quartz, feldspar limonite, magnetite, hematite, epidote and others.

In the manufacture of synthetic rubbers the nature of the filler powder materials has been shown to be of great importance.

For instance it can be shown that the structure of Kalvan and Gilder's whiting is the same as calcite. If other forms of $CaCO_3$ such as aragonite were substituted, it could be readily identified.

Other materials such as carbon blacks, metallic inclusions, rutile and anatase in TiO_2 and other pigments and fillers can also be differentiated.

Catalysts

The field of catalysis is so large and the materials used as catalytic agents so varied that it is only possible to give a brief description of some applications of the x-ray methods that can be employed in such studies.

A catalytic process that is exciting more interest as time goes by is the familiar Fischer-Tropsch process which is at present employed for the synthesis of liquid and solid hydrocarbons from H_2 and CO. The catalytic agent employed consists of Ni or Co or both, with activating materials such as alumina, thoria or other difficultly reduceable metal oxides[3]; kieselguhr has been used as a carrier. For such a catalyst a typical formula might be as follows:

Nickel	60	parts by weight
Manganese dioxide	20	parts by weight
Thoria	4-8	alumina, tungstic oxide or uranium oxide
Kieselguhr	125	parts by weight

The particle size of the nickel can be determined by the half-width-intensity method, and controlled for optimum yield. The phase of MnO_2 present can also be identified and controlled by previous conditioning. The activator may possibly contain substances that would act as catalytic inhibitors, and by simple x-ray identification methods, detected and eliminated chemically.

The kieselguhr carrier has to be previously pre-

pared by suitable chemical and thermal treatments to achieve uniformity, and the absence of harmful impurities. This treatment can be followed closely by x-ray powder diagnosis so that optimum conditions are employed.

By small-scale laboratory tests before the catalyst is placed in service, it is possible to determine the optimum conditions of operation for the catalyst with due consideration to economic life by following the changes in particle size and other characteristics, with time and temperature. After such correlating data are obtained, it becomes a relatively easy matter to control a large-scale operation by sampling the catalyst at regular intervals and obtaining an x-ray pattern for study.

In the use of Fe-Cu precipitated catalysts, it has been demonstrated that all active catalysts[4] contained FeO and that the activity was least, when sharp x-ray diffraction lines were obtained. This is due to the presence of many large crystallites. Small crystallite size gives diffuse lines, and this provides a means of control of the preparation of the catalyst.

Work by LeClerc and Lefebre[5] showed that the enhanced activity obtained by the addition of alkali carbonates to cubic Fe_2O_3 is due to the stabilization of the crystal form and prevention of the transition to Fe_3O_4 which is a less active catalyst.

The three iron oxides each have entirely different diffraction patterns and may be quantitatively determined and identified by x-ray means. Thus, the correct amount of alkali carbonate necessary to prevent transition of one form to a less active form can be easily determined.

Deactivation of a catalyst can be due to a great number of reasons other than particle-size increase, or poisoning.

In the Ni-Cu system it has been stated[6] that the Ni-Cu catalyst is composed, in the active state, of a dispersion of Ni in Cu.

Copper containing less than 1 part per million of iron was found to be inactive in the hydrogenation of benzene. If activated with 1 percent Ni, the copper reduced 60 percent of the benzene in 30 seconds at 175° C.

The catalyst heated at 350° C for 2 hours loses 33 percent of its activity due to the formation of a solid solution in Cu.

This change was determined in the original experiments by the loss in magnetic properties of the nickel as it went into solution in the copper.

The catalytic activity of a substance such as a zinc oxide catalyst[7] or activated carbon[8] is shown to be directly proportional to the surface area or can be correlated directly to particle size measurements. Recent published work follows the changes in activity along with particle size with heating in an alumina catalyst[9] and shows the changes in the x-ray scattering both in the low-angle range and the Debye-Scherrer powder diagrams for this material. Upon heating the catalyst, the diffuse lines of gamma alumina, on the Debye-Scherrer diagrams, become more and more sharp until finally alumina or corundum is obtained.

This method of determination of average particle size by the broadening of the Debye-Scherrer powder pattern is most effective when the diameter of the particles is less than 10^{-5} cm. With larger diameter particles the lines do not broaden appreciably.

The Scherrer formula for the measurement of crystallite size from x-ray powder diffraction lines can be expressed as follows: $L = \frac{0.89\lambda}{B_e \cos \theta}$

Where: L = average crystallite diameter in A°
θ = Bragg angle of measured line
B_e = corrected breadth of half width intensity (radians)
λ = wave length of radiation employed

The term B_e is a corrected value that requires several factors to be brought into consideration such as instrumental constants, pinhole size, the nature of the specimen and others.

The whole problem can be greatly simplified by making use of the newly developed X-ray Geiger-Counter Spectrometer, which has variable slits and negligible specimen absorption. Correct settings enable the half width value B_e to be absolute, for the purpose of particle size evaluation and consequently a better value can be more easily obtained.

The aging processes of thin palladium layers used as catalysts were studied[10] and it was found on studying the x-ray diagrams, that the fatigued layers had crystal sizes 250-1000 Å while the crystal sizes of the fresh layers of metal were less than 40 Å.

By a study of the effects of crystal size on absorption it was found that the absorption velocity of hydrogen on layers of small crystal size was considerable and independent of pressure, large size crystals gave lowered velocity of absorption which is strongly influenced by pressure.

X-ray studies of the use of promoters with catalysts have lead to the theory that such promoters must be able to build mixed crystals with the catalyst.[11,12] The x-ray spectra obtained from such promoters on a catalyst is usually indistinct and it has been shown that its chief action is in the prevention of growth of the crystallites.

Studies of Mineral Substances

There are comparatively few natural materials that are decolorizing materials or can act as such after suitable treatment.[13] While a chemical or spectrographic test can identify a clay mineral, the exact crystallographic form may not be so obvious. X-ray diffraction analysis can perform this task easily, and at the same time give a considerable amount of other information concerning particle size, degree of hydration, presence or absence of major contaminants, and other pertinent data. Such evaluation of a clay before elaborate and time consuming activation procedures are undertaken, is highly desirable if only from an economic standpoint.

It has been postulated[14] that in order to obtain the maximum activation from decolorizing earths, the carbonate content should be less than 3 percent. Combined carbonates can easily be identified and controlled in the activation process by following the change in the carbonate lines in the x-ray spectra.

Some earths of high bleaching power are characterized by a high content of crystallites of the montmorillonite type.[15] They are composed mainly of calcium and magnesium aluminosilicates. The calcium and magnesium on the surface of the crystallites is loosely held and can be replaced by other ions, e.g.—the hydrogen ion. This reaction has been used to select earths capable of activation, but the use of interpretation of x-ray studies for the purpose gives surest results.

Taking three typical decolorizing clays such as

montmorillonite, kaolinite and fuller's earth, the following observations can be made:

1. Each has entirely different spectra.

2. Dehydration at 1000° C. modifies their internal structure. For example, kaolinite becomes effectively amorphous after dehydration.

3. Certain lines disappear with dehydration—

Montmorillonite	14.7 Å
Fuller's earth	10.9 Å
Kaolinite	7.3 Å

4. Dehydration affects the low-angle scattering pattern (the distribution becomes entirely different).

5. Upon dehydration the diffraction maxima become diffused, indicating reduction of effective particle size, or poor crystallinity of the product.

The particle size seems to be intimately connected with the activity of the clay and can be measured by computation from the half width of the diffraction lines[16] or from the small-angle scatter data.

Since particle size is thus shown to be of pronounced significance in connection with decolorizing activity, it follows that there must be an optimum size at which the decolorizing agent will operate best. By designating significant numbers to the particle size, and correlating this with activity, the time-temperature relationship of the activating process can be determined and followed closely with a consequent increase in efficiency and economy.

Zeolites, which are hydrous silicate minerals, occur naturally in volcanic rocks, and can be divided into two classes: (a) Those containing alkaline earths with silica and (b) aluminum silicate. Silicates of class (a) exchange their base to a slight extent, while those of class (b) exchange their bases readily and completely. From these can be prepared, calcium, manganese and other zeolites, that can be used for the extraction of dissolved salts in water. X-rays show the nature of these exchanges and the fact that the zeolite lattice is practically unchanged by the exchange.

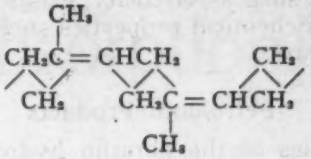
The zeolites are numerous and differentiation between the hydrate forms (b) such as scolecite and natrolite and the non-hydrated formation of others, such as heulandite, thomsonite, analcite, mesolite and chabazite can be easily carried out by x-ray identification.

Recent references to clays and their x-ray data can be found in various sections of the literature[17,18,19,20] that will assist in their identification.

High Polymer Studies

Within recent years great technological advances have been made in the manufacture and uses of polymeric substances such as rubber and plastics. These materials are characterized by a large molecular weight that may be between 50,000 and 300,000. For instance, slightly masticated rubber gives a value of 270,000 which indicates that the carbon chains contain between 20,000 and 30,000 carbon atoms. This means of course that the rubber molecule is very complex and the structure practically impossible of solution by chemical methods alone. X-ray analysis, however, gives a precise structure which fits the rubber molecule.

According to Meyer and Mark[21] cis-configuration of rubber possesses a structure as shown below:



Unstretched rubber gives a typical amorphous x-ray pattern which is not very useful for practical application in obtaining information about the material. However, fiber diagrams can be obtained from stretched rubber due to its anisotropic properties.

For the unequivocal indexing of an x-ray diffraction pattern, x-ray diagrams of more highly orientated preparation are necessary; these may be obtained for examples by using a thin film of dried latex extended and compressed, and irradiated by the x-radiation at right angles to the film. This tends to give a pattern of the planes at right angles to the film. The crystalline regions in stretched rubber have been estimated and values given of length (along the fiber axis) > 600 Å, width $\backsim 500$ Å and thickness $\backsim 150$ Å.

These values lead to the assumption that the crystallite is a long flat bundle and that rubber can be brought to a high degree of orientation with comparative ease. Besides this orientation, it is possible to demonstrate by a study of x-ray diagrams of frozen stretched rubber film that double orientation is possible.

When rubber is stretched 80 percent or more at room temperature, the spots on the fiber diagram become approximately more intense in proportion to the degree of stretching while their position remains more or less the same. This demonstrates that the degree of orientation in the rubber can be increased by mechanical working.

The addition agents such as zinc oxide, gas black, magnesium carbonate, barium sulphate, diatomaceous earth, clay and other materials are used mainly as acceleration activators, reinforcing agents, and fillers. The particle size and mineralogical nature of these materials is known to be of great importance to the quality of the finished rubber, and must be kept under careful laboratory control. X-ray diffraction studies offer one of the best methods of control so that the standards of reproducibility may be met. Chemical analysis is rarely sufficient and is very laborious.

Due partly to x-ray studies, the theory of rubber elasticity was propounded and the process of co-polymerization developed. This changed the objective of the synthesis of rubber to the development of long-chain polymers of any constitution having rubber-like properties. The most important of these at present are co-polymers of butadiene and styrene or acrylic nitrile (buna-S and buna-N), polymerized 2-chlorobutadiene (neoprene), and polyethylene polysulfide (thiokol).

The synthetic rubbers generally show a greater sensitivity to the nature of the addition agents than natural rubber, and for that reason it is more than ever necessary to keep close control of such materials.

The effect of the addition of 50 parts of different

TABLE 1

	Tensile Strength Kg/cm²	Breaking Limit of Extension Percent	Load at 300 Percent Extension Kg/cm²
Active black	275	650	80
Half-active black	180	550	60
Inactive black	150	500	70

(High Polymers, Vol. IV, Kurt H. Meyer, p. 184)

grades of carbon black to 100 parts of buna-S are shown in Table 1.

Generally speaking, in the study of high polymeric substances, x-rays can assist greatly in the study of the unit cell, the nature of which controls the physical properties such as viscosity, elasticity, and solidity, as well as chemical properties such as water and reagent resistance.

Petroleum Products

X-ray studies of the paraffin hydrocarbon group of compounds have shown that they form a close-packed layer structure and one dimension of the unit cell is much larger than the other. As the number of carbon atoms in the structure increases this long spacing increases also in uniform increments per carbon atom. The narrow dimensions of the cell remain essentially constant and so correspond to close packing of parallel chains of carbon atoms.

The type of pattern obtained is usually a strong single line for the long spacing followed by a large succession of other lines due to other orders of reflection. (Where $n = 1,2,3$ etc. in the Bragg Law relationship $n\lambda = 2d \sin \theta$).

The long spacing value per carbon atom for a homologous series of paraffin hydrocarbons is known to be 1.25 Å per carbon atom. The small dimensions are usually about $a = 7.45$ Å and $b = 4.97$ Å.

It has been found by x-ray examination of fractionated waxes from used Mid-Continent petroleum, that the fractions are mixtures, in which the fraction having the largest spacing value gives the highest melting point.

The calculated molecular weights from x-ray data are 25 percent higher than the ebullioscopic method, which indicates that the fraction contains lower molecular weight paraffins than the major component.

Diffraction patterns of the pure aliphatic acid series show an alternation of intensities of line maxima, so that the odd orders are strong, and even orders are weak. This phenomena is true up to about the ninth order when the intensities even out. Beyond this point the even orders become strong while the odd orders become weak.

The polymorphism of long-chain substances can be studied by differing methods of sample preparation. For instance, the spacing values and intensity data are entirely different when polymorphic substances are melted and solidified than if they are crystallized and pressed on a flat specimen plate.

The position of atoms in isomeric substances is readily determined by the variation in intensities of different orders which enables the form to be identified.

It has been found that while a molecular-weight determination can be made with a pure long-chain hydrocarbon, and identification of each phase can be made where there is a mechanical mixture of two members of the homologous series, a melt and subsequent solidification of the two, will give a value for the long spacing between that of the two parent substances. In the aliphatic acid group it will be noticed also that the second and third order reflections will tend to become less sharp, and the intensity relationship to become equalized in such solidified melts.

Heat Exchanger Problems

The problem of identification of corrosion products and boiler scales in heat exchangers is quite a critical one for the petroleum industry. Since such materials are sometimes formed under conditions not usually found in nature it is not surprising that their origin is sometimes difficult to trace, which makes any corrective treatment somewhat experimental.

The type of scale found in high-pressure boilers can contain a great number of elements which, of course, can be identified chemically and spectrographically. This information, however, is inadequate since it does not indicate the form in which the scale exists. X-ray analysis can uniquely and quantitatively identify the constituent of the polymorphic material, no matter how complicated it may be. This information determines the pre-treatment the water must have, to prevent such a formation, as well as indicating the type and concentration of acid required to remove the scale.

The matter of heat exchanger deposit identification is dealt with quite thoroughly in the literature.[3,4]

Thus it can be seen, that x-ray diffraction is a most valuable tool taking its rightful place with the more time-honored methods of analysis and supplementing rather than displacing them. For a complete analysis of materials neither the x-ray diffraction study, spectrographic analysis, or chemical analysis, will alone give a complete picture. A combination of all three methods, however, will give the most effective analytical information possible and certainly the most useful.

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Increasing Propane Recovery

In Existing Natural Gasoline Absorption Plants

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THIS paper summarizes the problem of increasing propane recovery in existing gasoline absorption plants. Four things are discussed that can be done without making expensive or radical changes, and with a minimum of shutdown time. These are:

Use of a lighter absorption oil.

Use of refrigeration on the lean oil and rich gas deethanizer overhead.

Use of stabilizer bottoms recycle to the still final condenser.

Use of the deethanizer control method as described.

This paper was presented before the April, 1945, meeting of California Natural Gasoline Association.

BECAUSE of the continued interest in propane as a substitute for butane in liquefied petroleum gas, and as an intermediate in chemical conversion processes, it is appropriate to consider methods by which its recovery can be increased in existing gasoline absorption plants. In a previous paper presented before the California Natural Gasoline Association, Henry Wade[1] presented an excellent discussion of the principles involved in the design of new plants for high propane recovery. These same principles apply to obtaining an increase in propane extraction in existing gasoline plants.

The problem may be considered in two phases, one, increasing the extraction of propane in the absorber rich oil, the other, retaining the propane thus recovered in the distillation and fractionation sections of the plant.

When considering means available for increasing propane extraction in the absorber, it is convenient to use the absorption factor as a basis. This may be defined as follows:

$$A = \frac{L}{KV}$$

where A = absorption factor
L = rich oil from absorber in mols per unit time
V = rich gas to absorber in mols per unit time
K = equilibrium constant for component under consideration, in this case propane, at absorber pressure and temperature.

Inspection of the absorption factor equation makes it obvious that an increase in the mols of rich oil, usually obtained by increasing the lean oil rate, or a decrease in the equilibrium constant, will result in an increase in the absorption factor, assuming the vapor rate is to be held constant. More simply, this means that an increase in the extraction of propane can be obtained by increasing the molal oil/gas ratio or decreasing the equilibrium constant.

An increase in the molal oil/gas ratio may be obtained in two ways, one by using a lighter oil giving more mols per gallon of oil circulated, the other by increasing the actual volumetric circulation rate. In an existing plant it may be quite expensive to increase the actual volumetric flow rate, since it would probably require new lean oil pumps, additional exchanger surface, and possibly revamping of the absorption and stripping columns. On the other hand, it may well be possible that a lighter absorption oil could be used in the existing equipment without increasing the vapor pressure of the lean oil to the point where lean oil loss becomes excessive. A summary of calculations made to illustrate the effect on propane extraction of increasing molal lean oil flow with fixed gas rate by the two methods mentioned is presented in Table 1.

TABLE 1

Effect of Increased Molal Oil Rate on Propane Extraction

Absorber Pressure.....135 psig — Temperature of Lean Oil..... 80° F.
No. of Theoretical Trays.....12 — Temperature of Wet Gas..... 80° F.

	RICH GAS		RICH OIL COMPOSITIONS					
			Case I		Case II		Case III	
	Mols/ Day	Mol %	Mols/ Day	Mol %	Mols/ Day	Mol %	Mols/ Day	Mol %
CO_2	2,378	5.71	77	.50	85	.50	85	.50
C_1	31,933	76.67	617	3.99	675	3.97	690	4.04
C_2	2,772	6.66	281	1.82	306	1.80	314	1.84
C_3	2,504	6.01	744	4.81	808	4.75	828	4.85
C_4	351	.84	222	1.44	240	1.41	246	1.44
C_4	920	2.21	773	5.00	814	4.79	834	4.88
C_{5+}	792	1.90	792	5.12	792	4.66	792	4.64
Lean Oil	.....	.....	11,954	77.32	13,290	78.12	13,291	77.81
Total	41,650	100.00	15,460	100.00	17,010	100.00	17,080	100.00
Lean Oil Rate, g.p.m.			205		205		228	
Lean Oil Gravity, °API			40		43.3		40	
Lean Oil Molecular Weight			170		150		170	
Absorption Temp., °F			102		103		101	
Dry Gas Outlet Temp., °F			84.6		84.9		85.1	
Propane Increase, percent			0		8.6		11.3	
Propane Increase, Gals/D			....		666		874	

NOTES:—Case I is the original design basis.
Case II illustrates the use of a lighter lean oil.
Case III illustrates the increase in volume rate of original lean oil required to obtain same molal oil rate as in Case II.

These calculations were made for an existing plant in which the butane extraction is fairly low, only about 78 percent in the absorber. By inspection of Table 1 it will be seen that a reduction of the lean oil mol weight from 170 as used in the plant at present, shown in Case I, to 150, as shown in Case II, will result in an increased propane extraction of 666 gallons per day, or 8.6 percent. The calculations summarized in Case III were made to demonstrate the effect of an increase in volumetric lean oil rate for the original lean oil that would be required to obtain the same molal oil rate as in Case II. For a 10 percent volumetric increase in the original lean oil, the same molal oil rate will be obtained as with the lighter oil, but the pounds of oil circulated will be materially increased, thus resulting in a somewhat lower absorption temperature due to the greater heat capacity of the lean oil. The 10 percent increase in volumetric lean oil rate gave an increase in propane extraction

of 874 gallons per day, or 11.3 percent. Since we are interested, in this paper, only in methods for obtaining an increase in propane recovery, we will not discuss in detail the effect of these changes on butane recovery, but should call to your atention the fact that an increase in butane extraction also resulted. In plants that are already obtaining high butane recovery there would be no material change in the butane extraction by these small changes in lean-oil rate.

No attempt has been made to evaluate the increase in absorption-oil loss when using the lighter lean oil, since it is quite possible to use a narrower-boiling-range oil with a lower endpoint without materially increasing the vapor pressure of oil from the still. In actual fact, it is likely that the use of a lighter oil may make it possible to obtain a greater volumetric circulation with the existing equipment, as the oil will have a lower viscosity, thus resulting in less pressure drop through the exchanger and lines. It also should be pointed out that the use of a lighter oil would result in fewer pounds being circulated per unit volume, so that the exchange equipment could easily handle the increase in volumetric oil rate up to the point where the weight of oil circulated equaled the original weight of oil. The problem of selection of absorption oil always should be given very careful consideration, both in existing plants and in the design of new plants.

The equilibrium constant may be decreased either by increasing pressure or decreasing temperature. In existing plants it is not ordinarily practical to increase the absorption pressure, so that we will consider only means for reducing the absorption temperature. This may be done by refrigeration applied to the lean oil, rich gas, or both. The distribution of cooling between the oil and gas should be carefully studied since it is possible to cool the oil too much without also cooling the gas. Consideration must be given to the heat of absorption, heat capacity of the oil and heat capacity of the gas to determine the proper distribution of cooling between oil and gas. Each case must be considered individually. A summary of calculations made to illustrate the effect of refrigeration on propane extraction is presented in Table 2.

The same absorption case was used in preparation of Table 2 as in Table 1. It was assumed that the oil or gas could be cooled to 60° F. from an original temperature obtained with water of 80°F. In all cases it was assumed that the volumetric lean oil rate would be held constant at 205 GPM with a rich gas rate of 41,650 mols per day. Case I illustrates the absorption obtained with water cooling only. Case II illustrates the effect of cooling the oil only. The propane extraction increased 880 gallons per day, or 13.8 percent. Case III illustrates the effect of refrigeration of the gas only to 60° F., resulting in an increase in propane extraction of 541 gallons per day, or 7 percent. Case IV illustrates the effect of refrigerating both the oil and gas to 60°F., resulting in an increase in propane extraction of 1653 gallons per day, or 21.4 percent. Since it is possible to use a lighter lean oil because of the lower temperature at the top of the absorber resulting in a lower partial vapor pressure of the oil at this point, it is desirable to include calculations showing the effect of combining a lighter lean oil with refrigeration. Case V illustrates the use of 150 mol weight oil in place of 170 mol weight with the lean oil only refrigerated to 60° F., giving an increase in propane extraction of 1748 gallons per day, or 22.6 percent. Case VI illustrates the use of the lighter lean oil with refrigeration of both gas and oil to 60°F., resulting in an increase in propane extraction of 2579 gallons per day, or 33.3 percent.

It should be pointed out that the temperature to which the streams can be refrigerated is limited by the point of hydrate formation. There are several references giving data on hydrate formation conditions, among which are Katz[2] and Bechtold[3]. Bibliographies included with these papers give practically complete coverage of the literature on hydrocarbon hydrates.

The equilibrium constant also can be reduced by using intercooling to obtain a reduction in the absorption temperature where the temperature rise without intercooling exceeds 15 to 20° F. No calculations are presented covering the use of intercoolers, but it should be pointed out that where intercoolers are used it is important that they be properly located in the absorber and that the oil circulation be maintained in order to increase the extraction of propane. The location of the intercoolers is a function of the

TABLE 2

Effect of Refrigeration of Oil and Gas to Absorber on Propane Extraction

Absorber Pressure — 135 psig No. of Theoretical Trays — 12

	RICH GAS		RICH OIL COMPOSITIONS											
			CASE I		CASE II		CASE III		CASE IV		CASE V		CASE VI	
	Mols/Day	Mol %	Mols/Day	Mol %	Mols/Day	Mol %	Mols/Day	Mol %	Mols/Day	Mol %	Mols/Day	Mol %	Mols/Day	Mol %
CO_2	2,378	5.71	77	.50	84	.53	81	.52	88	.55	90	.52	96	.55
C_1	31,933	76.67	617	3.99	669	4.24	652	4.17	698	4.38	725	4.19	767	4.38
C_2	2,772	6.66	281	1.82	316	2.00	299	1.91	333	2.09	339	1.96	366	2.09
C_3	2,504	6.01	744	4.81	847	5.37	796	5.09	903	5.67	912	5.27	992	5.67
C_4	351	.84	222	1.44	256	1.62	241	1.54	279	1.75	274	1.58	302	1.73
C_4	920	2.21	773	5.00	855	5.42	821	5.25	884	5.55	878	5.07	903	5.16
C_{5+}	792	1.90	792	5.12	792	5.02	792	5.06	792	4.97	792	4.58	792	4.53
Lean Oil	.....	.....	11,954	77.32	11,956	75.80	11,956	76.46	11,953	75.04	13,290	76.83	13,282	75.89
Total	41,650	100.00	15,460	100.00	15,775	100.00	15,638	100.00	15,930	100.00	17,300	100.00	17,500	100.00
Temperature Gas in, °F			80		80		60		60		80		60	
Temperature Gas out, °F			84.6		68.3		78.5		54		65.9		62.5	
Temperature Oil in, °F			80		60		80		60		60		60	
Temperature Oil out, °F			102		92		97		86		94		86	
Absorption Temperature, °F			102		92		97		86		94		86	
Lean Oil Rate, g.p.m.			205		205		205		205		205		205	
Lean Oil Gravity, °API			40		40		40		40		43.3		43.3	
Lean Oil Mol Weight			170		170		170		170		150		150	
Propane Increase, percent			.....		13.8		7.0		21.4		22.6		33.3	
Propane Increase, Gals/D			.....		880		541		1653		1748		2579	

NOTES:—Case I—The original design basis. Oil and gas in at 80° F. Case II—Lean oil only refrigerated to 60° F. Case III—Rich gas only refrigerated to 60° F. Case IV—Lean oil and rich gas both refrigerated to 60° F. Case V—Lighter oil used with same volume rate as before. Lean oil only refrigerated to 60° F. Case VI—Same as Case V, with rich gas and lean oil both refrigerated to 60° F.

gas/oil ratio which affects the temperature gradient in the absorber. In general it is difficult, from a mechanical standpoint, to add intercooling to existing equipment.

Another way in which the propane extraction may be increased is by the addition of trays in the absorber or by improving the tray efficiency of existing absorbers. Increasing the number of absorption trays is effective on propane extraction only where the absorption factor is between approximately 0.6 to 2.0, depending on the number of theoretical trays in the existing absorber. This may be understood readily by reference to the Brown[4] absorption factor diagram. Revamping or addition of absorber trays is a somewhat expensive and mechanically difficult task in an existing plant.

The next phase to be considered in the problem of increasing propane recovery in existing absorption plants is the retention of the propane in the distillation and fractionation steps. Since every plant will differ in the matter of venting and stripping of the rich oil, these problems must be considered for each individual plant by someone competent to make the necessary process study. The main problem is to determine how best to dispose of the increased pickup of methane and ethane in the rich oil necessarily resulting with the increased propane extraction. The still vapor may be recycled to the main absorber or reabsorber, compressed and condensed, or compressed direct to the stabilizers. The amount of the still vapors may be materially reduced, or even entirely eliminated, by the use of stabilizer bottoms recycle[5] to the still final condenser. It should be noted, however, that stabilizer bottoms recycle is effective only where the vapor pressure of the stabilizer bottoms product is considerably less than the vapor pressure of the still overhead product. This means that in general the still accumulator pressure must exceed 50 psig for effective use of stabilizer bottoms recycle. One point which might be overlooked when attempting to use stabilizer bottoms recycle is that it is necessary to obtain thorough mixing of the recycle liquid with the still product vapor in the condenser, which requires that the condensers, where atmospheric, be of the upflow type, or where shell-and-tube to give the necessary mixing by effective baffling.

It is often desirable to recycle only a sufficient amount of the stabilizer bottoms to prevent the still overhead vapor from building up a high internal cycle through the absorption step. Where stabilizer bottoms recycle is used to reduce or eliminate recycle vapors to the absorbers the advantage is twofold since it reduces or eliminates recompressor horsepower and makes the lean oil available for primary absorption of the plant inlet streams rather than secondary absorption of recycle gas.

The final point to be considered is retention of the propane in a deethanizer column. This is another place where refrigeration should be considered because it is possible to reduce the amount of propane loss required for the production of reflux for this column by reducing the condensing temperature. The temperature to which the deethanizer overhead vapor may be refrigerated is again limited by the hydrate formation temperature.

One more thing that should be considered in connection with the deethanizer is the method of control to be used for maximum retention of propane. This is illustrated in Figure 1 in which is shown a flow-rate controller on the steam to the reboiler to obtain constant heat input with a liquid-level controller on the reflux accumulator controlling the reflux returned to the column so that all liquid condensed in the overhead condenser will be returned as liquid to the column. By the use of constant heat input to the column to obtain the desired stripping of ethane from the bottoms with a return of all liquid formed in the overhead condenser maximum retention of propane is obtained regardless of cooling-water temperatures.

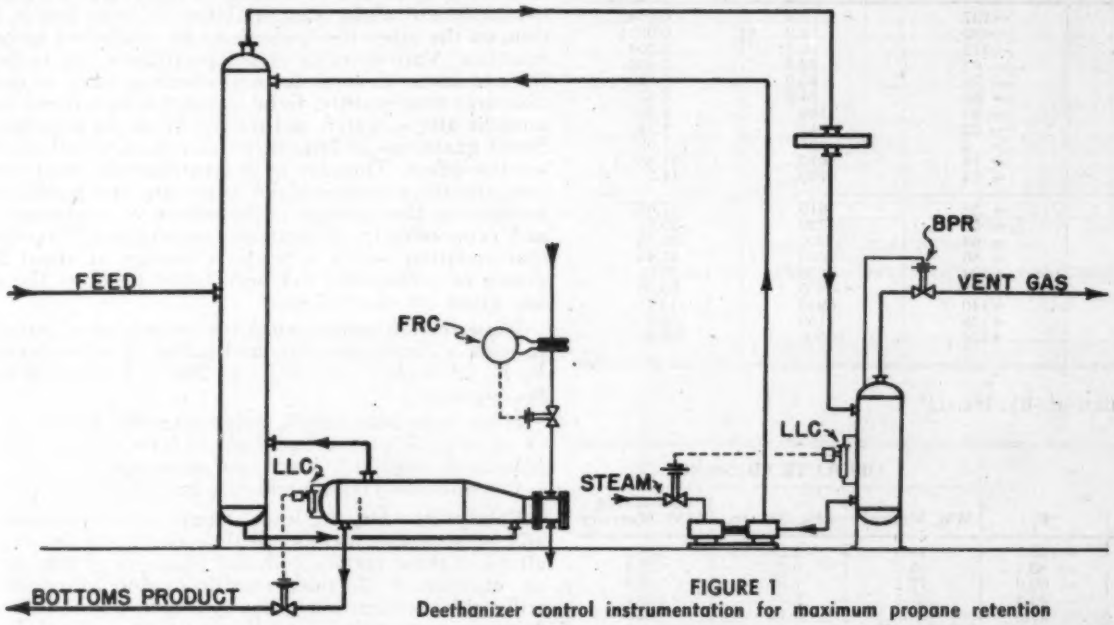

FIGURE 1
Deethanizer control instrumentation for maximum propane retention

All of the methods should be given careful study to determine their economic feasibility before making any changes in a plant.

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Physical and Chemical Properties of Butadiene

(Pittsburgh-Des Moines Steel Company Chemical Storage Fellowship, Mellon Institute)

Physical Properties

1. Formula: $CH_2 = CH - CH = CH_2$; C_4H_6.
2. Molecular weight: 54.088.
3. Normal physical state: Gas, colorless, aromatic odor.
4. Specific gravity as a gas (Air = 1): 1.877.
5. Boiling point as a liquid:[1]
   (a) —4.7° C. (23.54° F.) at 760 mm., or 14.7 lbs./sq. in.[2]
   (b) —4.4° C. (24.08° F.) at 760 mm., or 14.7 lbs./sq. in.[3]
6. Specific gravity as a liquid (water at 60° F. = 1):
   (a) 0.6263[4]
   (b) Chart I: Mean of data
7. Specific heats as a liquid and vapor:
   (a) 0.61 at 68° F.[5]
   (b) Chart II.[4]
8. Vapor pressure:
   Tabulation (a):[4]

°C.	°F.	MM. Mercury	Lbs./Sq. In.
—94	—137	3.0	0.0582
—90	—130	4.2	0.0814
—80	—112	10.5	0.204
—70	— 94	22.5	0.436
—60	— 76	45.0	0.873
—50	— 58	84.0	1.63
—40	— 40	146	2.83
—30	— 22	247	4.79
—20	— 4	393	7.62
—10	+ 14	610	11.83
— 4.4	+ 24	760	14.7
0	+ 32	910	17.65
+10	+ 50	1320	25.61
+20	+ 68	1900	36.85
+30	+ 86	2650	51.40
+40	+104	3610	70.01
+50	+122	4800	93.09
+60	+140	5940	114.7
+70	+158	7150	138.7
+80	+176	10500	203.6

Tabulation (b): Heisig[5]

°C.	°F.	ABSOLUTE PRESSURE		
		MM. Mercury	Lbs./Sq. In.	Calculated MM. Mercury
—75.5	—103.9	14.6	0.283	16.1
—63.4	— 82.1	35.4	0.687	37.4
—51.6	— 60.9	77.1	1.50	77.8
—39.4	— 39.3	153.4	2.98	153.7
—38.6	— 37.5	161.7	3.14	160.5
—32.7	— 26.9	219.0	4.25	216.6
—26.1	— 15.0	301.4	5.85	298.3
—19.9	— 3.8	400.5	7.76	397.8
—15.5	+ 5.9	484.2	9.39	482.6
—10.4	+ 14.7	599.9	11.63	599.1
— 5.6	+ 21.9	729.7	14.16	731.0
— 1.5	+ 31.1	854.0	16.57	859.0

$$\log_{10} P\ (\text{mm}) = \frac{1251.8}{T} + 7.543$$

T = absolute temperature
1.0 lb./sq. in. = 51.715 mm. mercury

   (c) Chart III[4]
9. Critical temperature: 325.7° F.[4,6]
10. Latent heat of vaporization: Chart II.[4,7]
11. Latent heat of fusion: 63.5 Btu per lb.[8]
12. Coefficients of expansion as a liquid:
   (a) 0.001022/° F. between + 5° F. and + 70° F.[4]
   (b) 0.00184/° F. between — 15° C. (+ 5° F.) and 20° C. (68° F.)[2]
13. Explosive limits in air:
   (a) 2 to 11.5 percent by volume[9]
   (b) 1.63 to 9.9 percent by volume[9]
14. Pounds of liquid per U. S. gallon: 5.225 at 60° F.
15. Refractive index: 1.422 at 21.2° F. $\frac{20^{20},\ 11}{D}$
16. Specific volume of vapor: 6.46 cu. ft./lb. at 32° F. and 14.7 lbs./sq. in.
17. Melting point as a solid: — 163.67° F.[3,10]
18. Solubilities: Slightly soluble in water, methanol, and ethanol; readily soluble in ether, benzene, carbon tetrachloride, and chloroform.[13]

Chemical Properties

The most prominent chemical property of butadiene is that of dimerization and polymerization. Dimerization is apparently not catalyzed by oxidizing reagents, or by the type of surface. However, polymerization is catalyzed by active oxygen whether it is in the form of air, molecular oxygen, ozone, ozonides, or peroxides—organic or inorganic.[14] The mechanism of polymerization of ethylene compounds in general has been generally explained by Ostromyslenski in 1915.[15]

Numerous investigators have studied the effect of various inhibitors upon the formation of polymers of butadiene. A list of the currently cited inhibitors is given below. Dimerization, on the other hand, seems to be unaffected by any known inhibitor. Various rates of polymerization are to be found in the literature. Several factors affecting rates of polymerization are: temperature, light, contact with various metals and metallic alloys, water, and the purity of the butadiene studied. Small quantities of impurities have been found to exert noteworthy effect. The rate of polymerization due to increase of temperature is economically important and justifies the maintenance of the storage of butadiene in containers at a low and economically determined temperature. The specific recommendation which is made is storage at about 32° F. Increase of surface has not been found to affect the rate under any given set of conditions.

Dimerization results when two molecules of butadiene unite to form a ring-type compound called "3-ethenylcyclohexene." B. P. 129.5-130.5° C. (265.3 to 266.9° F.) at 760 mm. (14.74 lbs./sq. in.).

High molecular weight polymerization results in the union of many molecules of butadiene to form long open-chain compounds of negligibly low vapor pressures.

Lists of catalyzers, inhibitors, and modifying agents:

Catalyzers: Air, tin, lead, stannic chloride, metallic sodium and other alkali metals, alkaline earth metals, amalgams or alloys of these metals, colloidal platinum or mercury or silver or manganese dioxide, metallo-organo compounds, boron trifluoride, barium peroxide, hydrogen peroxide, sodium perborate, ammonium persulfate, organic peroxides, organic peracids, sulfur, starch, oleates of sodium, ammonium, and cobalt, sodium stearate, albumen, casein, urea, soap, saponine, glycerine, and dioxan.

Inhibitors: Tertiary butyl catechol, hydroquinone, tricresol, phenyl-β-naphthylamine, diarylamines, and 1, 8 diaminonaphthalene.

Modifying Agents: Carbon tetrachloride, hexachlorethane, terchlorpropionitrile, sodium cyanide, mercaptans, xanthogendisulfide, thiuram disulfides, and sulfinic acids.

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Physical and Chemical Properties of Butadiene

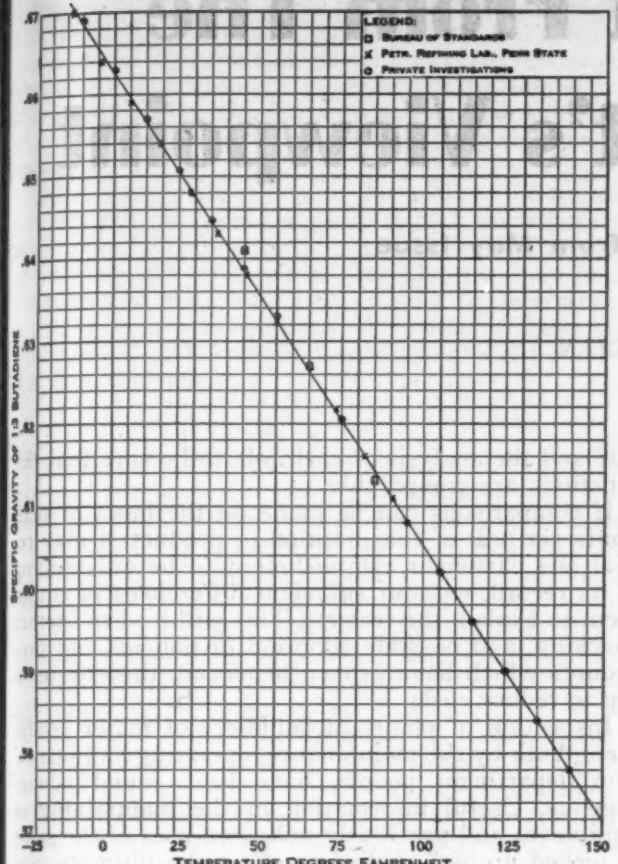


CHART I — SPECIFIC GRAVITY OF 1:3 BUTADIENE LIQUID

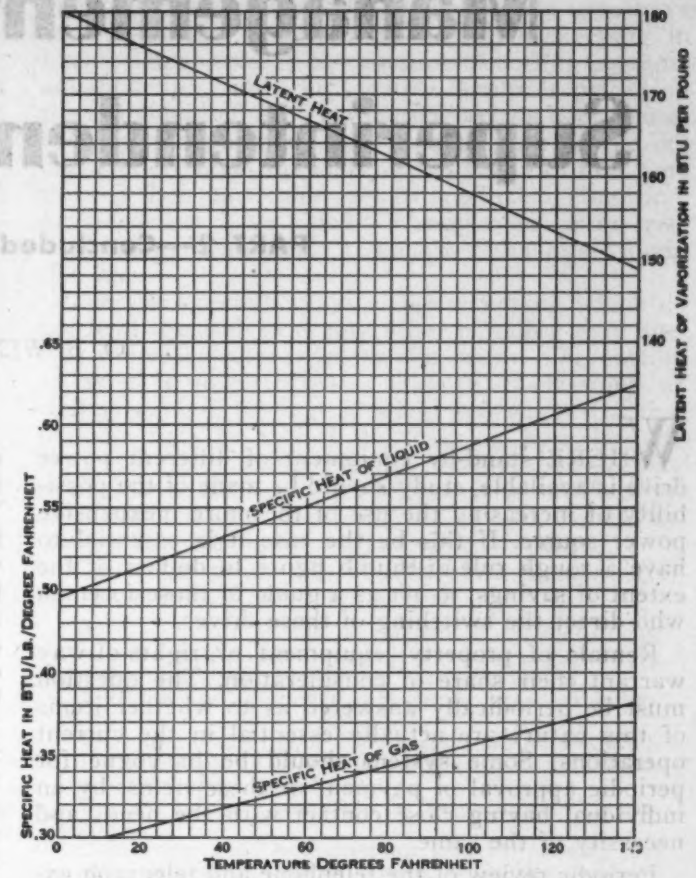

LATENT HEAT
SPECIFIC HEAT OF LIQUID
SPECIFIC HEAT OF GAS
SPECIFIC HEAT IN BTU/LB./DEGREE FAHRENHEIT
LATENT HEAT OF VAPORIZATION IN BTU PER POUND
TEMPERATURE DEGREES FAHRENHEIT

CHART II — LATENT AND SPECIFIC HEATS OF 1:3 BUTADIENE

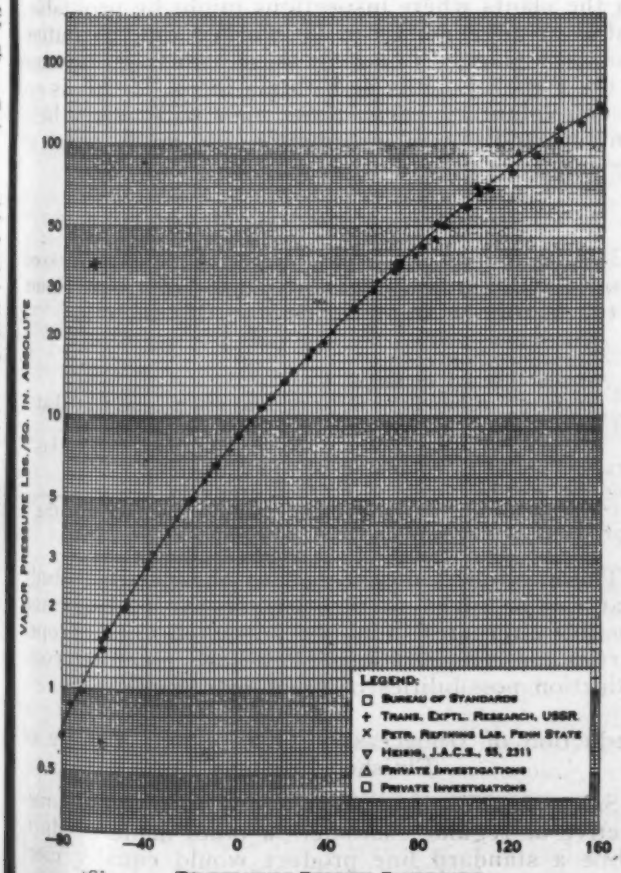


CHART III — VAPOR PRESSURES OF BUTADIENE

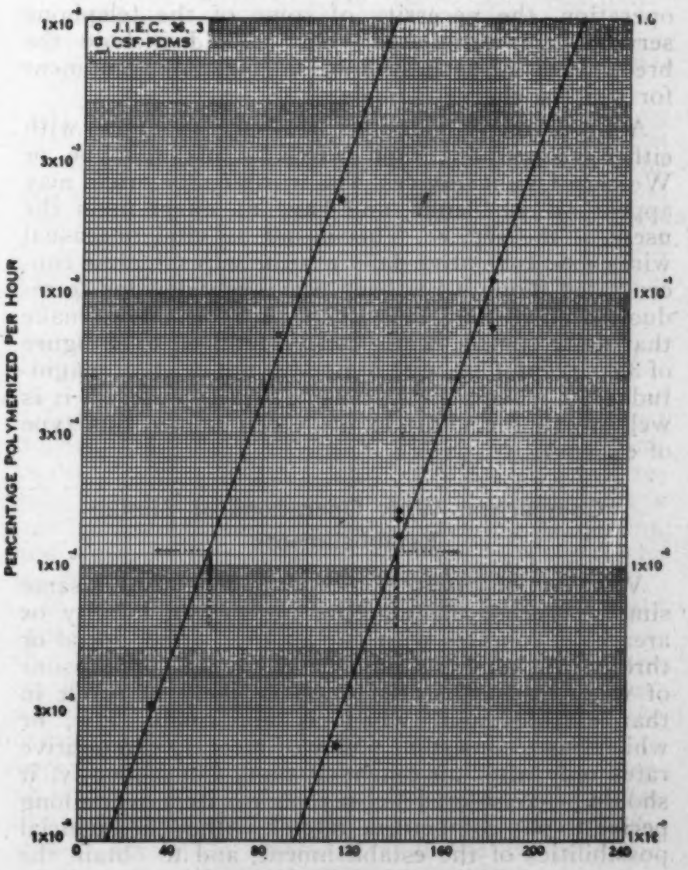


CHART IV—RATE OF POLYMERIZATION OF LIQUID BUTADIENE

Management From The Superintendent's Viewpoint

PART 2—Concluded from May Issue

O. B. WENDELN

WHERE stand-by equipment of different power drive is available, study should be made of the possibility of increasing the use of the more inexpensive power source. If this be the case it is essential to have a rough rule-of-thumb figure in dollars of the extent of savings, to act as a guide to those foremen who direct the switching of these drives.

Rentals of property, equipment or rights-of-way warrant their share of consideration. The question must be periodically answered as to whether items of this nature are actually essential in the current operations. Some system should be in vogue for periodic approval of payment of these items, by an individual having close contact with the needs and necessity of the same.

Periodic review of the telephone and telegraph expenses if they be of any magnitude are likely to be well worth the effort. Due to altering conditions of operation, the necessity of some of the telephone services are antiquated. This should include the break down of each station and piece of equipment for which a charge is made.

A great many manufacturers are provided with either private telegraph wires or use teletype or Western Union services. The wording "be brief" may appear on all blanks, and have no effect upon the users of the service. This is not so vital on casual wires, as it is relative daily routine wires. Unless concentrated thought has been previously devoted to reduction in wording, it is a very safe estimate to make that daily routine wires can be reduced by a figure of 33 percent. One wire in itself is not of great magnitude, but when a year's business is considered, it is well worth the effort expended to reduce this type of expense.

Comparison With Operations of Similar Establishments

Workers of different concerns but of the same similar type of manufacture in a given locality or area have contacts with one another, either social or through their unions, and thereby make comparisons of wage rates. Dissatisfaction is likely to result in that establishment which is abnormally low, or which has a consistant policy of meeting competitive rates only after an extended time. Consequently, it should be considered a cost economy item over a long period to pay competitive rates if within the financial possibilities of the establishment, and to obtain the asset accruing from the greater satisfaction of the workers. This involves a study of each and every rate and the analysis of each job, to be sure that the functions are comparable.

If comparisons can be made on the basis of man hours per unit of consumption or product, it may reveal one particular establishment to be outstanding in its record, without sufficient differences in equipment to explain the reasons. This will lead to further checking, and possible adoption of policies and procedures which have proven beneficial, thereby tending to reduce costs.

Inspection of plants of suppliers of major equipment, both by the maintenance, operating and inspection department people, have been found advantageous. Useful information in the maintaining of equipment and previously unknown uses of the same is picked up and applied to effect the ultimate goal of cost reduction. It should be to advantage for the foremen group or some one in the management, to list the plants where inspections might be profitable, and if arrangements can be worked out, a routine should be planned to permit these men to go to some of the establishments and obtain ideas. If this is on a semi-voluntary basis, these men will make these contacts and obtain information and apply some of the details in their daily responsibilities.

Economics of the Raw Material

The suitability of the raw material to be processed is one of the most important phases of costs. Some of the factors having a bearing on this include:

The initial cost.
Transportation cost.
Availability of material.
Necessity of handling this material due to the fact that it might be already owned.
The depreciation effect upon the equipment of this raw material as compared to other material.
The possible yields of finished products.
The additional treating and handling costs of the products of this raw material, as compared to others.
The possible quality of the finished products.

These subjects deserve all of the detailed study that can be given to them, while the findings and possible alternates should be presented to the proper parties for consideration. They have potential cost-reduction possibilities of great magnitude.

Reduction of Unnecessary Quality and Variety of Finished Products

Sales organizations are inclined to promise prospective or regular customers a tailor-made product, while a standard line product would equally meet the requirements. This results in excessive manufacturing costs as well as excessive inventories, which

is not always passed on to the customer. It is difficult for the foreman in a plant to recognize where these consolidations can be made, unless there is some contact with the needs and necessities or the sales requirements. Neverthless, it will pay to review the products manufactured, to endeavor to establish if there is sufficient similarity to warrant consideration of consolidating many products into fewer finished products.

If control specifications on the quality of a finished product can be altered slightly it may materially reduce manufacturing costs, not only from the actual processing and yield angles, but also the man hours consumed in inspecting this product to determine if it meets these specifications. A review of these possibilities on each control specification will be worth the time and effort.

Costs of Safety

The actual dollars and cents cost of injuries, and its resultant costs in doctor and hospital fees, compensation and insurance payments, as well as salary payments during the injury may be an item of major or minor magnitude, depending upon the establishment. As dollars expended on items of this nature are distinct losses and cash out of pocket, they should be kept to a minimum or avoided. But from a humanitarian angle alone, it is essential that the best precautions possible be taken to avoid accidents.

It is very difficult to economically substantiate a great many of the expenditures promoted in the interest of safety, as the enthusiasm of certain individuals along safety lines is likely to exceed their better judgment. Each item which is suggested should be fully weighed prior to any rejection, and good common horse sense applied as to logic of the item.

There are as many different safety set ups as there are establishments in industry to bring out safety consciousness. A few generalizations will be of assistance in suggesting others:

Safety suggestion boxes appear to be of questionable value over an extended period.

Comparative safety campaigns with other plants are generally thought to be of value in stimulating interest.

Safety committee inspections by both a rotating employe group as well as a foreman group, have proven very successful. It is essential to give the rank-and-file worker an opportunity to express himself relative the safe working conditions of a plant in which he is working. He is much more likely to express his ideas along safety lines to a fellow worker on the committee than to a foreman or by any other means.

Safety bulletin boards and displays are heartily endorsed, although excesses have been observed.

Investigations and reports of accidents by both a rank-and-file employe committee, and a foreman group, with recommendations as to how to eliminate future occurrances have shown indications of merit.

A study of the various accidents as to type, listing in sequence of magnitude, and concentration on those of greatest frequency have corrected many poor conditions.

But the most important of all methods of attack is to do a thorough selling job to the foreman and employe groups on preventative corrections for accidents or in other words, "safety thinking."

Costs of Housekeeping

The payout or economies in housekeeping is a most intangible problem. On the debit side are the initial costs of drainage, landscaping, painting, etc., and the maintenance costs of cleaning, sweeping, cutting lawns, painting and others. On the credit side are the general impressions to outsiders, and the psychological effect of the workers in their endeavor to do their job just a little better. Good housekeeping and efficiency go hand in hand.

One means of accomplishing good housekeeping is to have a force specifically delegated for this purpose, handling nothing else. The other extreme is to have each individual maintain his own housekeeping in his particular area. A combination of both is the most advantageous, with the greatest emphasis placed on the individual effort. This thereby avoids poor housekeeping and unsightly appearances prior to the occurrance. A great majority of workers can find time to keep their particular area in good clean condition, provided they have a definite assignment as to area, and receive some credit in some way for effort along this line.

There are certain types of housekeeping which do not lend themselves to any other handling than specific individuals assigned to this work. The cutting of lawns in some instances may be so classified, as well as some of the janitor work. It is suggested that periodic lists be drawn up covering housekeeping work done by maintenance or routine housekeeping employes, to determine if plans can be worked out on individual items, whereby these jobs can be advantageously assigned to the operation people.

Numerous means can be employed in sponsoring housekeeping. A few suggestion:

Assignment of specific equipment to individuals for appearances. If possible, metal labels to be placed on the equipment bearing the name of the individual.

Likewise the assignment of specific areas to individuals.

Photographing of poor housekeeping before and after. This is difficult to follow through on a routine basis, and get the effect.

Use of safety committees as inspectors of housekeeping.

Publicizing good housekeeping jobs by pictures and articles, either on bulletin boards or in the company magazines, to effect greater effort by other individuals or departments.

Extensive planting of grass areas and shrubbery have a tendency to cause each employe to maintain his equipment and area in a cleaner and more efficient condition, and creating a certain pride of the plant in which he is working.

Whether a certain housekeeping item should or should not be consumated, because the rapid payout of the project cannot be determined, or because the project would have no obvious utility, is a question which frequently comes up for discussion and decision. It is realized that there are extremes in all cases, but due weight should be given the psychological effect upon the workers in a clean plant.

Increase in Efficiency Due to Improvement of Working Conditions

Lighting conditions are probably one of the most important phases of working conditions. If lighting facilities are inadequate, poor workmanship will result. Many of the electric utility companies offer a free light meter service to survey existing equipment, and make specific recommendations. Use should be made of this service.

In some establishments light loads are a relatively large percentage of the total load while lighted, although they may be a relatively small per cent of the total monthly bill. If maximum demands occur during the lighted period it may have a bearing on the overall monthly bill. It will be to advantage to survey the lighting situation to endeavor to determine which light loads could be discontinued either temporarily or permanently, without loss of efficiency. The study should arrange the switches and services in sequence of wattage magnitude, and this taken into consideration in the study. It will not pay

to be penny wise and pound foolish, but under certain conditions and arrangements, the dollar magnitude of this item is worthy of consideration.

That buildings should be adequately heated in winter for maximum efficiency is an accepted rule. But there are frequently some buildings, large and small, which are being heated which do not need heating.

Should air conditioning or even fans be considered for a portion of the jobs for summer weather to improve efficiency of the workmen? Air circulation alone may be the adequate corrective step. The proper insulation of lines and equipment may be the answer to the ventilation problem at hand. Refrigeration of drinking water usually can be economically substantiated from savings of running water alone.

The subject of "eye ease" in relation to efficiency of work is a technical subject in itself. Lighting has a great bearing on this, as well as, for instance, reflections from glass top desks. One subject which has not been given much consideration is the use of "eye ease" paper and forms. Paper has been noted on the market with a light green background and slightly heavier green lines, taking the place of harsh yellow pads of paper, for the specific purpose of "eye ease." Printed blank forms are as a rule in black and white. Forms made of light brown paper have been observed, with darker brown lines, for the specific purpose of "eye ease." The penciled or typed figures stand out on this brown form, as compared to the normal black and white forms.

Necessity and Advisability of Shift Work

Considering maintenance work only, a great many concerns require a 24-hour continuity of operation on a three-shift basis. Others operate under normal conditions on a day shift only, expanding to a two-shift operation when maintenance work demands.

Over a period of time where there is continuity of operation for all shifts, it will probably be found that an excessive number of individuals have been assigned to these shifts, to take care of all possible contingencies which might arise. If these men can be assigned to day work, where more efficiency and greater supervision is possible, costs have a possibility of being reduced. The emergencies which might arise can still be taken care of by "call backs," even though it involves an additional rate, without involving a greater payroll expense for the work accomplished.

Losses Due to Temporary Assignments at a Higher Rate

The procedure of temporary assignments at a higher rate is somewhat extensively used. The first reaction to this is that there is no dollar loss involved in the use of temporary assignments at a higher rate, as the establishment is receiving normal value in return for the higher rate. But over a period of time the total labor charges are going to be greater with excessive temporary assignments. A minimum amount of temporary assignments indicates a healthy condition, in that the particular classification of employes is just about adequate to handle the scheduled work.

The greater portion of temporary assignments usually are found to occur at times of peak loads of work, which is necessary to be completed by a certain time. A study of the details of the temporary assignments will reveal that a portion of them are made at other than peak loads. It is this section which bears investigation, to determine if by more extensive planning the work in question could have been handled when the man hours in the regular classification were available. This phase of costs usually warrants the following of its trends and details, depending upon the extent of the sums involved.

Losses Due to Overtime

Assuming that time and a half is paid for overtime, it can be said that the half time paid is a direct dollar loss. It is realized that overtime can be eliminated by the employment of additional men, but this may be more costly than judiciously planning and handling the necessary minimum overtime.

This type of cost is of sufficient importance to determine its extent by keeping a monthly and yearly tabulation and index in some establishments. This will further permit planning of ways and means to effect reductions.

From a personnel relation standpoint, the matter of distribution of overtime is of prime importance. It would not be out of line to estimate that 50 percent of the grievances which arise in some establishments are resultant from inadequate thought and planning on overtime distribution. It is essential to keep a cumulative record of the overtime allotted to each man, and effort be made to equally distribute the necessary overtime in a particular classification, craft or department, over a period of time. If this is done the possibilities of favoritism disappear.

Necessity of Making Entire Staff Cost Conscious

Usually it can be said that most every foreman group in a manufacturing industry is cost conscious, and that each step which he takes is with the item of costs in mind. But as there are so many varying degrees of this attitude, it is obvious that the maximum benefit is not obtained.

The sub-foreman in a department usually has more practical detailed knowledge as to practices and practical procedures than any one in the supervisory group, even though it may not be complete technical knowledge. It is upon his decisions or recommendations that a great many of the daily dollars are spent, under the advice of his superiors. But in a great many cases this man considers the matter of costs to be of secondary importance, for he is held responsible to get the job done, with a fair but firm personnel relationship with the men under him.

It would be to advantage to get each one of these sub-foremen to place more emphasis and thought on costs. If all of the sub-foremen in the establishment or plant would think along this line to a larger extent than formerly, it would have a greater effect than just management alone thinking along the lines of costs.

One means is to make definite assignments as to responsibility for costs to various sub-foremen, or each type or unit of costs to be assigned to some individual. Upon being furnished the details as to his dollars experience, a very concrete evidence is at hand as to whether he is getting the job done in a better or worse condition on a dollar basis than formerly.

Included in the management group and answerable to top management only, should be an individual or group whose specific function should be to develop ways and means to reduce costs, in those plants of sufficient size to warrant or justify this set up. This department should not be burdened with the

time-consuming routine of the daily operations, to hinder their thought along their specific assignment. If this set up cannot be justified, it is necessary that management handle the situation. The final answer to any problem need not necessarily be developed by this cost department, as its purpose would be to locate questionable or suspicious looking items to be referred by the management to the foreman group; or to locate questions for references to this same group to develop thinking along a desired line, and to obtain the effect of greater cost consciousness.

Cooperation on Cost-Reduction Procedures

Voluntary cooperation in cost-reduction work is obtained from the sub-foremen, but it is very slight in a great many cases, until at least very concrete dollars savings can be definitely proven. The average foreman may resent this statement, and in some establishments this may not be the case, but getting the work done is the item of first consideration in the majority of cases.

Assuming that management is sold on cost reduction, as that is one of the major items by which he is judged, and assuming that management is in favor of spreading cost responsibility to the entire foremen group, the question to answer is how shall it be done. It has to be done by the management itself, through his staff, with nearly the same emphasis upon this phase as it placed upon the necessity of actually doing the job. Reasons for this necessity can be given and explained by management, but if placed upon a strictly voluntary basis, the end will not be accomplished. Individuals are prone to want to do things in the future as they have done them in the past.

Cooperation on cost reduction items can not necessarily be obtained by just placing emphasis on costs. Also cooperation is obtained not because of a foreman's like or dislike of his superior, but because the foreman recognizes that management is assuming the responsibility of the entire organization under his scope, including his own bread and butter.

Budget control when broken down into individual departments and items, although a very necessary and important phase, may in itself be worked around to a point where it shields gross inefficiency. The above statement is based on the premise that budget-control figures are based, or weighted on past experience, without extensive thought on ways and means in accomplishing reductions. Explanations of any item exceeding the budget are accepted, unless grossly out of line with the facts, without further thought of reduction.

Budget work permits planning of future expenses. It also permits control over current expenses, and if properly used it is an indication of points where there are possibilities of reduction of costs.

Consideration should be given to have each sub-foreman review his costs each period or month to his immediate superior in writing if possible. A summary from all sub department sources should be compiled, along with the overall survey. Although a report of this type may be lengthy, and filled with alibis, it would broaden the base of cost consciousness, and could be used as the basis of start of corrective steps for reductions. A report of this type is equally important as any report or summary on actual or physical operations per period. Mental or educational limitations may be cited as a draw back for such a program, but it is still possible to an extent, if handled gradually, and these particular limitations kept in mind in making the assignments.

The individual establishment will have to decide how far budgeting, planning, and cost work should go. The generalization can be made that for check-up purposes the foreman group desire their cost picture the same day or the day after if possible, and unless such is the case the data frequently are deemed useless by them in every-day control of their departments. In certain industries this control is considered essential, is established, and is profitably used. In others, citing the other extreme, no attempt is made to present a daily picture of costs in departments, but a preliminary monthly estimate is made and used pending the receipt of the official expenditure picture about 30 days subsequent to the close of the period.

It is a matter of economics as to which plan to adopt. It is doubtful if full use is made of either plan in many cases. The up-to-the-minute cost data are valueless unless the foreman uses the information to control or decrease costs, and does more than merely make routine explanations on excessive items. On the other hand the foremen's reaction to the set up with the time lag is that it is "water over the dam," and its value is thereby slight. But actual study of this back history compared to standard practice or budget set up, has great possibilities of effecting corrective steps. Both extreme procedures if used at all tend to promote cost consciousness. And both methods can be used as the basis of the suggested monthly summary costs previously mentioned for furtherance of cost consideration.

Consideration should be given for the department head, and sub-foreman to assist or at least offer their opinions as to the details, when compiling the budget. These men, who actually spend the money, should have some part in building the plan of expenditures for the subsequent period.

Possibilities of reducing costs frequently necessitate capital expenditures to rearrange or install new equipment. An application usually is made, to make funds available, citing reasons, economics and payout of the proposal which has been developed. The sources of these possibilities may originate from the worker, the foreman or the management.

Subsequent to final approval, installation and operation, there are occasions when the savings and economics which were anticipated do not materialize, and no subsequent thought is devoted to the item. A report on each completed job should be made nevertheless, comparing estimates and actual costs, and including the actual payout or accomplishments of the job. This should be done by the foreman who originated the job, for the psychological effect and his guidance in future items. At least he should receive a copy of such a report, if it be necessary for someone else to prepare the same. These steps will tend to make the foreman more cost conscious.

It can be arranged to have each department head give informal talks on costs in his department, to other department heads or foremen. The necessary study to be able to give these talks will cause the department heads involved to have a better grasp of the costs in their own and other departments.

Discussions by the management or cost department itself would also be of benefit, but the greater the distribution of these cost talks, the more benefit should accrue to the overall cost picture.

Each foreman usually is held responsible for completing and handling the job under his jurisdiction,

and the costs in doing so. Primarily he is held responsible for getting the job done, and that is where he is likely to spend the greater portion of his time. The assumption is correct that these men are aware of costs, and that costs guide their actions, but usually they have no systematic routine established to further their knowledge of costs due to press of other functions. It follows that if cost consideration is more intensively worked upon by the key foremen, in due course the foremen under them and the workers will more intensively work upon costs and use it as a guide in their every day functions.

The foreman can be assisted in arranging for time for study of costs. One means is to get him to analyze his job. This will reveal items of a non-supervisory nature which can be either discontinued or passed down to the non foreman worker. Certain time-consuming items, but of an essential nature might more advantageously be assigned to another department, to permit the foreman to devote his time to problems of greater magnitude. It might be suggested to the foreman that he take a certain period each day, and devote that period religiously to the study of costs, except in cases of other emergency duties.

The item of the foreman doing the non foreman's work cannot be emphasized to strongly. The same may be questioned relative the department head doing the foreman's work, and likewise the question right up the line of the organization. The daily detailed information which the foreman receives, although valuable and useful, sometimes is inclined to be so burdensome that the broader picture cannot be grasped or studied. It is a foreman's continual fight to weigh the importance of each item confronting him, and decide whether it should be handled by himself or a subordinate. If one day's functions are reviewed, including even the subject matter of each telephone call, to discussions with employes as well as with sub foremen, and it is determined how many of them could have been handled by a subordinate without losing touch of the overall picture, a great amount of valuable time may be saved.

It is a most difficult task, even with a detailed analysis as outlined, to recognize and admit but that a very minor number of the functions listed could or should have been handled by any one else, without that particular foreman or individual losing touch and grasp of the overall picture of the department or phase for which he is responsible. If this is the case, it is necessary for the man's superior to throw the analysis away, and work from the angle of making assignments to this foreman covering those phases upon which he is spending an inadequate amount of time. Through force of necessity this results in the foreman passing the routine down to subordinates to provide adequate time to handle these new assignments. This procedure, although effective, is obviously not as desirable as that of self analysis.

If the amount of detailed knowledge and information relative the organization is spread so that the man at the bottom has the greatest detailed knowledge but the least grasp of the overall picture, and the individual at the top has but very little detailed knowledge and greatest grasp of the overall picture, this would be what is usually deemed the desirable set up. The assistants, the department heads and sub foremen would come in between these extremes with gradually varying degrees of knowledge and grasp. As this ideal is studied and approached the necessity for each worker and foreman can be substantiated.

Publicity

If accomplishments in cost reduction are hidden and not publicized, the desire and attainment of further reductions are nullified. Therefore, the right type of publicity is an important asset.

Publicity might refer to an individual in relation to a department, to a department in relation to the local management of the establishment, or it might refer to the local establishment's relations to the general office, but in this article it does not necessarily refer to the plant's relations to the public or the community.

It is essential to sell the general idea that this particular individual, department or establishment is functioning in the most efficient and up-to-date means possible. This idea must be repeatedly sold to each individual in higher authority, and each individual who has contacts with those in higher authority. It is necessary to be on the publicity offensive at all times, and not on the defensive if at all possible. When on the defensive of any particular situation or condition, it is possible to express opinions and quote obvious substantiating statistics and although perhaps perfectly correct, the time will be infrequent when one is able to convince the individual or group.

The offensive attack can be handled verbally, by letters, by company publications and in general appearances. It must not be done in such a manner that it is obvious. It must not be done in such a manner that it is obnoxious. It is necessary to be a diplomat as well as a salesman.

Articles or notes in some types of company publications are good means of publicity. The particular department or plant should be kept continually before the readers if possible. Also this can be used as a means of publicizing accomplishments such as safety and housekeeping achievements, to endeavor to get other individuals or departments to do likewise. The editors of a great many company publications welcome articles of general interest from foremen and rank and file employes. It is regrettable that very few of these groups make use of these facilities.

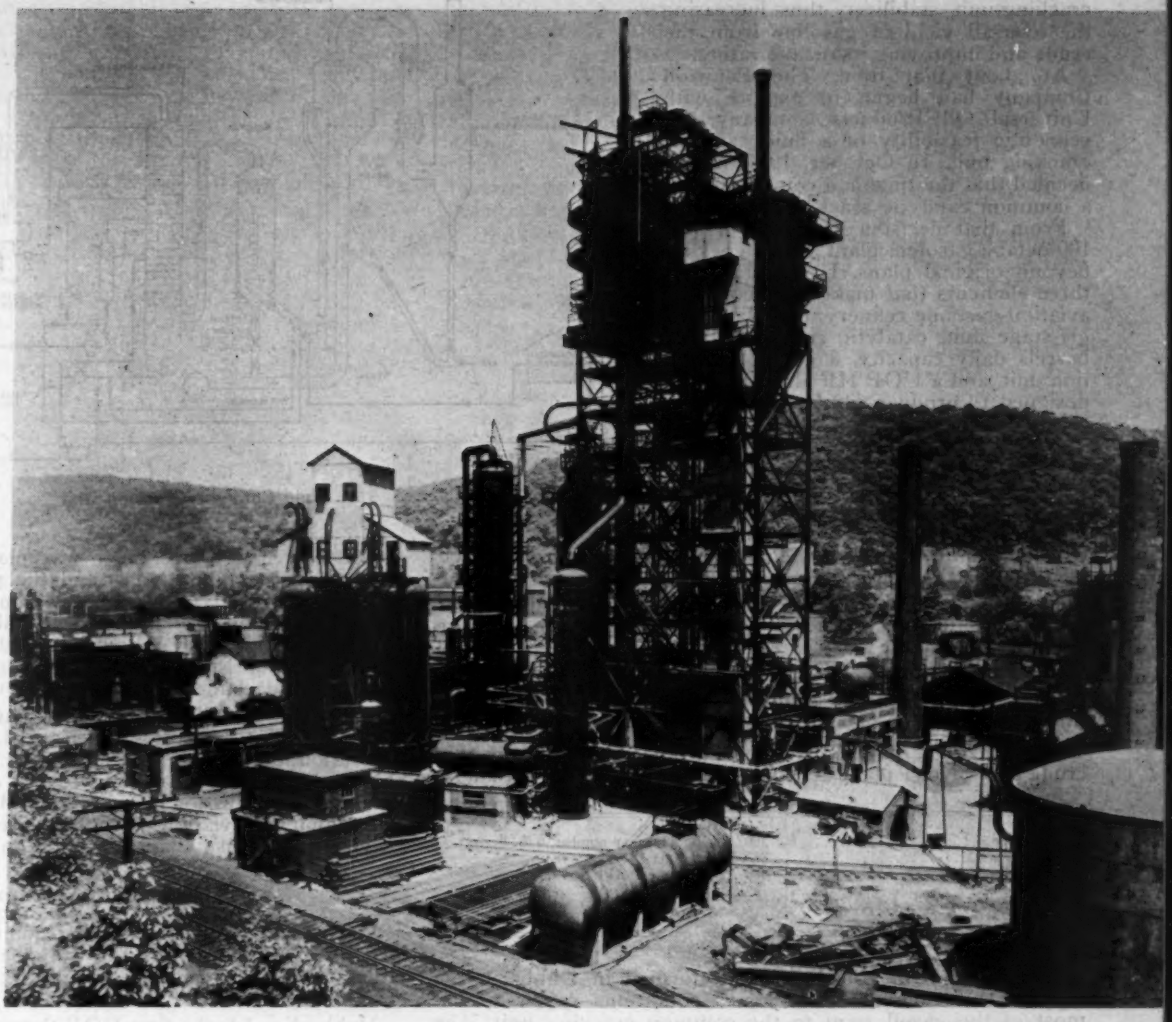
It is suggested that a systematic program of publicity be planned. Include in the study of this program a list of the items which might be so inefficient that publicity might not be advisable, and arrive at solutions as to how to improve them. Herein lies one additional tie-in between publicity, its reduction in costs, and probable help in victory. Be on the offensive!

Indicators

Common pH Range and Color Change

*Methyl violet	(yellow)	pH 0.15	— pH 3.2	(violet)
Thymol blue	(red)	pH 1.2	— pH 2.8	(yellow)
Bromphenol blue	(yellow)	pH 3.0	— pH 4.6	(blue)
*Methyl orange	(red)	pH 3.1	— pH 4.4	(yellow)
Bromcresol green	(yellow)	pH 3.8	— pH 5.4	(blue)
Methyl red	(red)	pH 4.2	— pH 6.3	(yellow)
*Resorcin blue	(red)	pH 4.4	— pH 6.2	(blue)
*Litmus	(red)	pH 4.5	— pH 8.3	(blue)
Chlorphenol red	(yellow)	pH 5.0	— pH 6.6	(red)
Bromcresol purple	(yellow)	pH 5.2	— pH 6.8	(purple)
Bromthymol blue	(yellow)	pH 6.0	— pH 7.6	(blue)
Phenol red	(yellow)	pH 6.8	— pH 8.4	(red)
Cresol red	(yellow)	pH 7.2	— pH 8.8	(red)
Metacresol purple	(yellow)	pH 7.6	— pH 9.2	(purple)
Thymol blue	(yellow)	pH 8.0	— pH 9.6	(blue)
O-cresolphthalein	(colorless)	pH 8.2	— pH 9.8	(red)
*Phenolphthalein	(colorless)	pH 8.3	— pH 10.0	(red)
Trinitrobenzene	(colorless)	pH 12.0	— pH 14.0	(orange)

* Indicators most commonly used.



This fluid catalytic cracking unit draws charging stock from four nearby Pennsylvania refineries.

Four Refiners Join to Convert Common Cracking Plant to War

PAUL TRUESDELL and W. E. LEMMEN, Universal Oil Products Company

A 100-OCTANE-GASOLINE plant in The Pennzoil Company's refinery at Oil City, Pennsylvania, represents extension into the war effort of a joint oil-cracking enterprise which was set up almost 15 years ago by four neighboring refiners. The Pennzoil Company, Quaker State Oil Refining Corporation, Wolf's Head Oil Refining Company, and Continental Refining Company.

The four joined in 1931 to install a 2500-barrel single-coil UOP thermal-cracking unit for their common use. It was named Dubbs No. 3. It replaced Dubbs Nos. 1 and 2 of 1000-barrel daily capacity each, which had been installed by The Pennzoil Company alone in 1927.

Dubbs No. 3 was the first joint cracking plant in the history of the industry. The owners did not form a corporation or a partnership. They were and are keen competitors, yet they have gone along amicably and successfully, their obligations defined and their rights safeguarded by nothing more than a mutual understanding set forth in a simple contract.

The satisfactory working out over the years of this informal agreement has demonstrated that, by joining forces, small refiners, even competitors, can enjoy the benefits of modern facilities that might be too costly for one to finance, and can effect economies together that no one of them could accomplish alone.

The No. 3 unit was built on The Pennzoil Company's land and is operated by that company. Each participating refiner supplies his proportionate share of cracking stock, bears his share of the costs and takes his share of the products. The Pennzoil Company furnishes more than half of the charging stock.

The Pennzoil Company alone, in 1932, installed a UOP thermal unit for reforming and once-through cracking, which was christened Dubbs No. 4. This is not a part of the common cracking plant.

In 1938, the four-company cracking unit was converted to 2-coil operation by addition of a light-oil heater and its capacity was increased to 4500 barrels a day. In the following year the associated refiners installed a 200-barrel-a-day UOP catalytic polymerization unit to polymerize the olefins in the

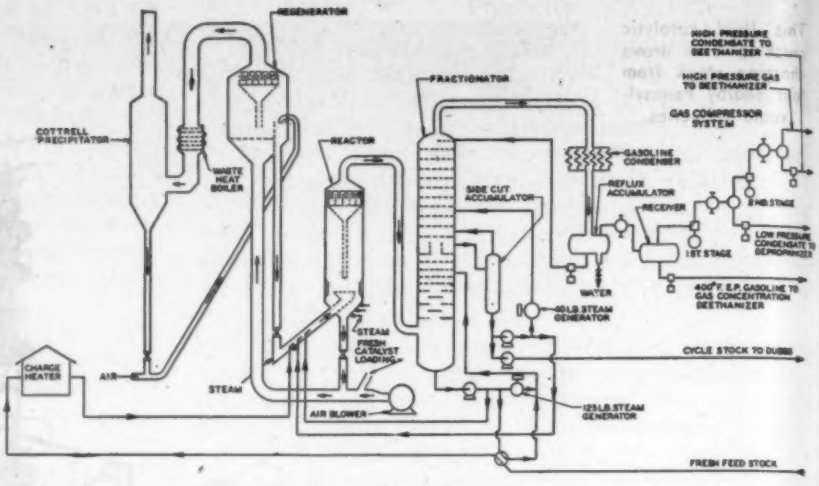
overhead condensate from the thermal-cracking-unit stabilizer, thus increasing the over-all yield of gasoline from the crude and improving its octane rating.

At about that time, The Pennzoil Company had begun to explore with Universal Oil Products Company, the economic feasibility of a fluid catalytic cracking unit. In October, 1941, it was decided that the time had come to install a common catalytic cracking unit.

From that decision grew the present 100-octane-gasoline plant which goes far beyond original plans. It comprises the three elements that make up a complete aviation-gasoline refinery, namely, a single-stage fluid catalytic cracker of 4500 barrels daily capacity, a gas concentration unit, and a UOP HF alkylation unit designed to produce 740 barrels per day of alkylate.

The catalytic-cracking unit, with the auxiliaries and alterations to other process units which it necessitated, cost more than $2,000,000, while the gas-concentration and alkylation units, with auxiliaries, which were financed by Defense Plant Corporation, cost well over $3,000,000 more. These facilities are operated by The Pennzoil Company under contract with the government.

These combined facilities are turning out 50 percent more 100-octane gasoline than they were originally expected to produce.



Fluid Catalytic Cracking Unit

Main Pennzoil Refinery

At the time the joint aviation-gasoline plant was projected, The Pennzoil Company was producing from Pennsylvania crude at its No. 1 plant at Rouseville, the following products:

S. R. gasoline	360° F. e.p., 52 octane number, 6 lb. R.v.p.
Kerosine (w.w.)	360-525° F. b.p., 45 API gravity
Light gasoil	400-700° F. b.p., 40 API gravity
Wax distillate	
Steam cylinder stock	

The straight-run gasoline was reformed in Dubbs 4, the kerosine was sold or cracked, as conditions required, and most of the gasoil went to the common cracking unit. The wax distillate and cylinder stock were processed into motor oil. A methyl-ethyl-ketone solvent dewaxing plant is under construction in Plant 1.

Ground was broken for the aviation gasoline plant in October, 1942. It was a combination conversion and new construction job. Universal Oil Products Company was the designer and licensor of the processes, Arthur G. McKee & Company was the engineering contractor.

The new facilities were placed on two separate pieces of land, and are known as Plants 2 and 3.

The new catalytic cracker was placed in Plant 2, where Dubbs No. 3, Dubbs No. 4 and the polymerization unit are located. The catalytic cracker was built on the exact site of old Dubbs 1 and 2. Plant 2 is two miles south of No. 1. The Quaker State refinery adjoins it on the south, and the plant of Continental Refining Company bounds it on the north. Wolf's Head refinery is at Reno, 6 miles away.

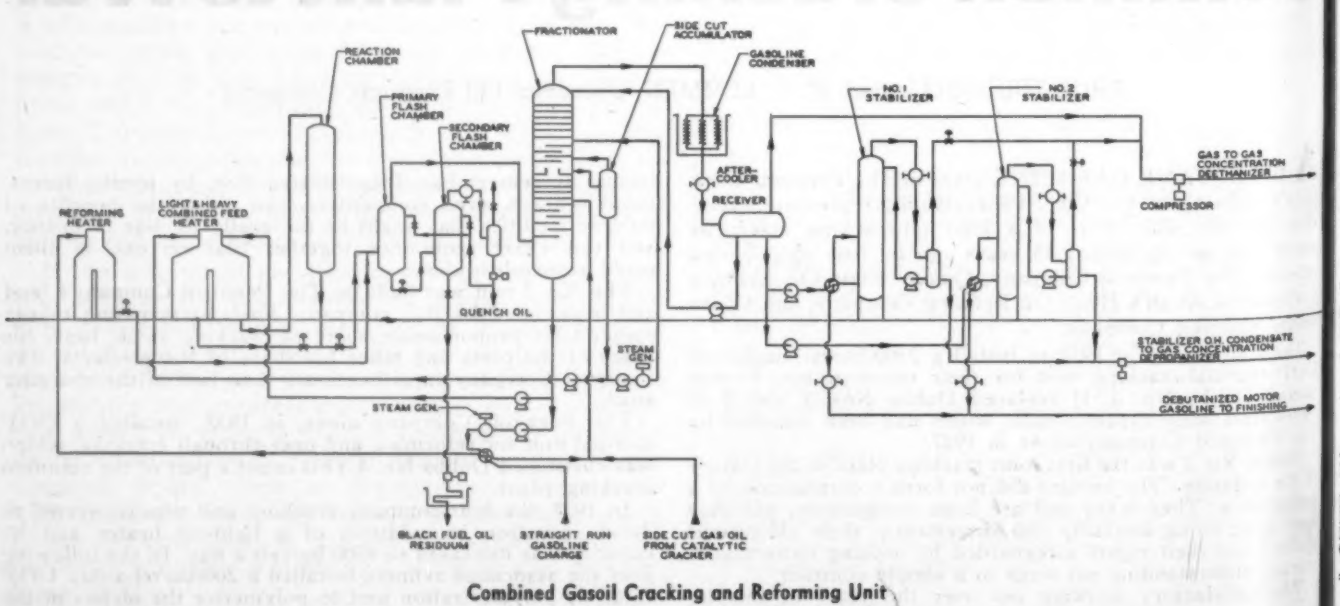
Plant 3, also called the D.P.C. plant, is a third of a mile north of Plant 2 on a 5-acre tract. It contains the gas-concentration unit, the HF alkylation unit, and the necessary utilities, including a new cooling tower, a new boiler plant and complete facilities for inhibiting, ethylizing, blending, storing, and shipping aviation gasoline. Everything in Plant 3 is owned by Defense Plant Corporation.

Thermal Cracker Converted

Dubbs No. 3 was the starting point in the war conversion program. In 1942, before the work began, the polymerization unit had been converted from motor polymer to codimer production.

Dubbs No. 3 is the first UOP thermal cracking unit ever to be tied into a catalytic cracking operation. The fractionator, which had almost reached the retirement stage for high-pressure operation, was found to be of suitable size to serve, with minor changes, as the fractionator for the catalytic cracker. So it was moved to the proper location and placed in a service which requires an operating pressure of only 5 pounds. A new tower, designed for 90 pounds pressure, was installed on the thermal cracker.

It was evident that under the new scheme, the thermal cracker would lose its old job, because the gasoil and kerosine



Combined Gasoil Cracking and Reforming Unit

formerly charged to it would go to the catalytic cracker instead. The only material available for thermal cracking would be catalytic cycle stock, amounting to 1500-2000 barrels per day, and straight-run gasoline. The original 2-cell heavy-oil heater of the thermal cracker, a 45,000,000 Btu per hour furnace, had sufficient capacity to handle all the catalytic cycle stock. Two-coil operation could be carried out by merely separating the coils, using one side for light and one for heavy oil. This was done, giving the unit a capacity of about 2500 barrels a day and effecting a substantial economy.

Through this arrangement, the light-oil heater, a 30,000,000 Btu per hour furnace, was released for use, without being moved from its original location, as a heater for the feed to the catalytic cracker.

A UOP center-wall updraft reforming heater, of 3500 barrels daily capacity, was added, so that the reforming of straight-run gasoline and cracking of cycle stock could be done in a single unit, thereby economizing on manpower and operating costs.

The remodeling of Dubbs 3 was carried on in such a manner that its operation was interrupted for only two months.

In its new role, this thermal unit is cracking about 1600 barrels per day of cycle stock and 2500 barrels per day of straight-run gasoline. The former is produced in the catalytic cracking unit.

The cycle stock is pumped directly from the fractionator of the cat cracker into the thermal-cracker fractionator, which operates at a top temperature of 370° F., bottom temperature of 615° F., and 93 pounds pressure. Heavy combined feed from the bottom of the fractionator is charged to the heavy-oil side of the heater and light combined feed, as a side cut from the fractionator, is charged to the light-oil coil.

Heat is recovered from the fractionating column by circulation of side-cut and bottoms through steam-generating heat exchangers, which together produce 18,000 pounds per hour of 125-pound steam. This method of heat recovery was installed as the economical way to relieve the load on an old and overtaxed boiler plant.

The heavy-oil stream leaves the heater coil at a transfer temperature of 915° F. and goes into the top of the reaction chamber which operates at 375 pounds pressure. The light-oil stream leaves the coil at 945° F. and joins the heavy-oil stream at the reaction chamber outlet, ahead of the pressure control valve.

Vapors from the reformer, leaving the heater at transfer temperature of 975-1000° F. and at a pressure of 500 pounds, are quenched with light oil to a temperature of 800° F., passing through a pressure-control valve and joining the other streams at the primary flash chamber inlet.

Overhead from the primary flash chamber enters the fractionator at a point below the inlet of the cycle stock. Primary-flash-chamber bottoms go to a secondary flash chamber operating at 30 pounds pressure and 525° F. temperature. Overhead from the secondary flash chamber is used as transfer quench and flash-chamber reflux. Bottoms from the secondary flash chamber, black fuel oil of 10° API gravity, represent about 10 percent of the gasoline-cycle stock charge.

Overhead from the fractionator goes to a receiver where liquid and gas are separated. A 2-cycle 200-horsepower gas-engine-driven compressor compresses the gases from 90 to 225 pounds, and delivers them to the deethanizer of the gas-concentration system for the recovery of C_3 and heavier hydrocarbons.

Unstabilized gasoline from the receiver goes to a pair of stabilizers operating in parallel as a debutanizer. The overhead condensate is charged to the depropanizer of the gas-concentration system. The bottoms are debutanized motor-gasoline fractions.

Feed to Dubbs No. 3

Straight run gasoline	360 e.p., 52 octane number
Catalytic cycle stock	36-37° API gravity, 400° F. I.B.P. 650° F. end point

Products from Dubbs No. 3

	Volume, Percent	Barrels per Day
Motor gasoline fractions, 400° F. end point, 64-65 octane rating 5-6 lb. RVP	72—77	2900—3100
Butylenes	5	200
Isobutane	1.5	60
Bottoms	10	410
Gas	9—12	.....

The butylenes and isobutane recovered make up a part of the charge to alkylation; thus, the thermal unit has a substantial part in the production of aviation gasoline, as well as in converting cycle stock and straight-run into motor gasoline.

Catalytic naphtha from the bottom of the rerun column of the gas-concentration system, and motor polymer when available, are blended with the thermally-cracked and reformed motor gasoline and its vapor pressure is raised to specifications by the addition of normal butane recovered from the thermal and catalytic BB fractions and separated in the debutanizer of the alkylation unit.

Dubbs No. 4 is employed by The Pennzoil Company alone as a stand-by for motor-fuel production, being used to crack excess gasoil or kerosine or to reform excess straight-run gasoline.

The catalytic-polymerization unit, which was robbed of its normal feed in the new arrangement, was modified so that it could process the gas-concentration depropanized overhead to produce motor polymer. This was accomplished by combining the depropanizer overhead and the normal butane stream from the alkylation-unit debutanizer in the poly unit feed drum, providing a liquid feed which can be processed without extensive alterations to the existing equipment. Normal butane thus recovered is combined with the debutanized motor-gasoline components along with the polymer.

The Catalytic Cracking Unit

Although the processes that take part in the production of aviation gasoline are interdependent, top honors for usefulness probably should go to the fluid catalytic cracking process because it is the largest producer of the components of 100-octane gasoline.

Those components are base stock, alkylate, and isopentane. The catalytic cracker produces all the base stock, most of the isopentane, and the greater part of the isobutane and butylenes which go to make up alkylate. In one method of operation, the cat cracker has produced from a virgin feed of 4300 barrels a day, these vital products:

	Barrels	Volume Percent
Depentanized 330° F. end point base stock	875	20.3
C_5 fraction	460	10.7
Butylenes	325	7.5
Isobutane	460	10.7

The 4500-barrel daily design capacity of the catalytic cracker was based on a charge composed of 3900 barrels of gasoil of 39-40 API gravity and 600 barrels of kerosine of 45 API gravity. It was expected that the gasoil and kerosine produced by the co-owners would be sufficient to supply the feed stocks in that ratio and in the quantities needed. Owing to shortage of Pennsylvania crude, that condition has not prevailed. Consequently, it has been necessary to purchase gasoil from other sources.

Under these conditions the catalytic-cracking unit has demonstrated its versatility. When sufficient fresh feed stock was available, the unit has cracked as much as 5000 barrels per day. It has run on charges ranging from straight gasoil to mixtures containing up to 30 percent kerosine. Even Illinois gasoil as low as 33° API gravity has been cracked without difficulty and with no serious effect on yields.

Operating conditions have been varied as much as charging stocks to meet special requirements. For instance, since isobutane became available from outside sources, the reactor temperature has been progressively increased to 950° F. in order to produce at the same time the maximum amount of butylene for alkylation and a base stock suitable for aviation blending without treatment other than a caustic wash.

During periods when output of 100-octane gasoline is limited by shortage of alkylate, the overall production has been increased by improving the quality of the base stock in a partial retreating operation in which 400° F.-end-point gasoline from the receiver is returned to the reactor along with the fresh feed.

Side-cut or cycle stock from the fractionator, which usually is cracked in Dubbs No. 3, has been recycled to the catalytic reactor in order to maintain maximum yields of base stock during periods when the supply of virgin charge stock was insufficient.

During the first two weeks in February, 600-700 barrels per day of recycle gasoline was charged to the unit, together

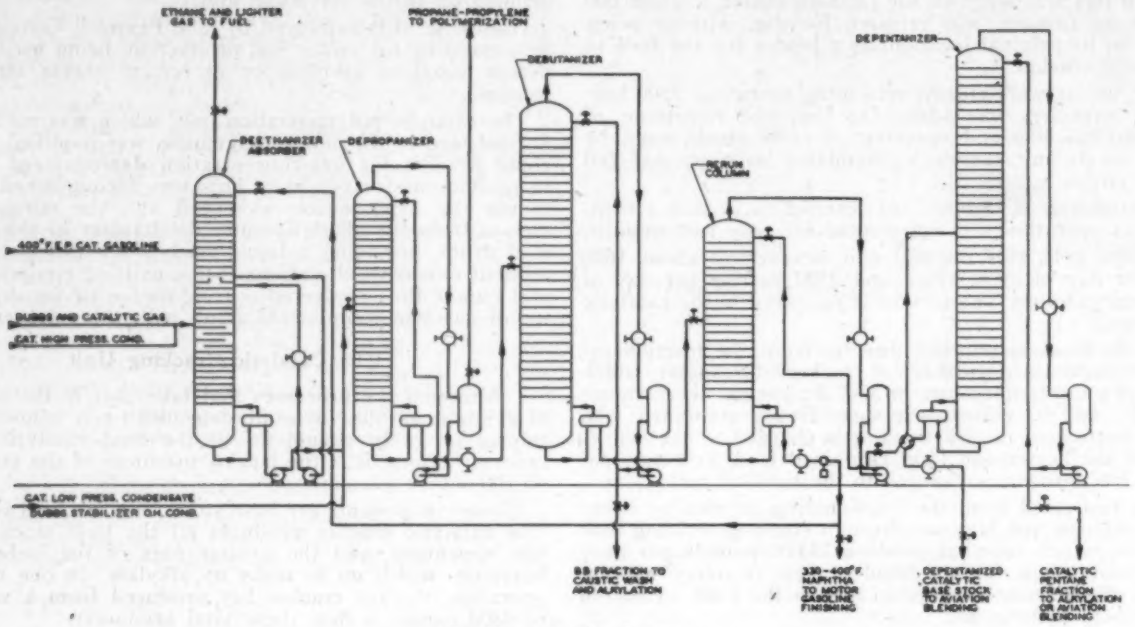
with 4000-4200 barrels of virgin gasoil in order to improve base-stock quality. Late in February, the operation was changed. Instead of recycling raw gasoline, 750-850 barrels per day of side-cut cycle stock was charged to the unit with 4300-4400 barrels of fresh gasoil, in order to increase the overall production of aviation gasoline.

When sufficient fresh feed stock again became available, recycling was stopped and the charge of fresh feed was increased to 4800-5000 barrels per day.

The fluid-catalytic cracking unit employs these three principles to carry out two main operations continuously and simultaneously:

1. Cracking oil in the presence of catalyst.
2. Maintenance of catalyst activity by burning off the coke deposited on the catalyst during the cracking reaction.

In order to minimize coke formation, and for other reasons, catalytic cracking is carried out at low pressure. The normal operating pressure in the reactor is about 10 pounds. The


ETHANE AND LIGHTER GAS TO FUEL
PROPANE-PROPYLENE TO POLYMERIZATION
DEBUTANIZER
DEPENTANIZER
DEETHANIZER ABSORBER
DEPROPANIZER
400° F. E.P. CAT. GASOLINE
DUBBS AND CATALYTIC GAS
CAT. HIGH PRESS. COND.
CAT. LOW PRESS. CONDENSATE
DUBBS STABILIZER O.H. COND.
B.B. FRACTION TO CAUSTIC WASH AND ALKYLATION
330–400° F. NAPHTHA TO MOTOR GASOLINE FINISHING
DEPENTANIZED CATALYTIC BASE STOCK TO AVIATION BLENDING
CATALYTIC PENTANE FRACTION TO ALKYLATION OR AVIATION BLENDING

Gas Concentration System

Yields from the operation when processing 3800 barrels per day of virgin gasoil and 700 barrels per day of side-cut cycle stock (calculated on fresh feed input basis) were:

Debutanised base stock	36.4 volume percent
Naphtha	7.1 volume percent
Light gasoil (cycle stock)	23.6 volume percent
Total C_4 fraction	26.4 volume percent
C_3 and lighter gases	12.8 weight percent
Coke	5.9 weight percent

Normal Feed Stock and Quality of Products

TYPE:—Gasoil	Fresh Feed	Debutanized Base Stock	Heavy Naphtha	Light Gasoil
Gravity	39.0	66.0	37.4	37.5
A.S.T.M. Dist.:				
I.B.P. °F	387	99	338	412
10	492	116	349	485
50	575	155	360	530
90	658	284	370	600
End point	705	327	417	665
Sulfur weight percent	0.01	....	....	....
Reid V. P.	9.1	....	....	....
Octane Number:				
AFD-1C clear	....	80.8	....	....
AFD-1C+4.6 cc TEL	....	91.1	....	....
AFD-3C+4.6 cc TEL	....	5—0.37	....	....

Composition C_4 Fraction Liquid

	Volume, Percent
Isobutylene	12
Normal butylene	24
Isobutane	53
Normal butane	11

Had this catalytic cracker been less flexible, production of aviation gasoline would have suffered severely.

The operation of a fluid-catalytic cracking unit is based on three main principles:

1. A catalyst consisting of finely divided solids will behave much like a fluid under the proper conditions of aeration.
2. The catalyst may be transported in air or vapor streams.
3. The catalyst will settle out into a dense phase when a stream of air or vapors carrying catalyst is introduced into a chamber of considerably larger diameter than the transporting line.

reactor is a 13- by 54-foot vessel mounted vertically near the ground.

The regenerator, operating at 1 pound pressure, is a 20- by 32.5-foot vessel elevated about 150 feet. The static head developed by a column of fluidized catalyst in a vertical pipe off the bottom of the regenerator, known as the regenerated catalyst standpipe, is sufficient to feed catalyst into the reactor. The regenerated catalyst standpipe has an inside diameter of 18 inches.

Fresh oil feed passes through a heat exchanger in which its temperature is raised to 300° F. by exchange with a portion of the slurry circulating stream from the bottom of the fractionator, and thence to the heater in which the temperature is raised to 750° F.

The partially vaporized charge enters the catalyst section at the line through which catalyst at a temperature of 1050-1100° F. is circulated to the reactor. This line is the injector. About 1300 pounds per hour of steam is introduced at the injector, to assist the mixing of catalyst and oil. The catalyst from the regenerator supplies the greater part of the heat required for vaporizing and cracking the charging stock. Current operation is carried out with a reactor temperature of 950° F.

The reactor temperature is largely a function of the regenerator temperature, the catalyst circulation rate, and the preheat on the oil feed to the reactor. A constant temperature is maintained in the reactor by minor adjustments of the catalyst circulation rate and preheat on the fresh feed, while the regenerator temperature is allowed to vary within a 50° F. range.

With a regenerator temperature of approximately 1100° F., the catalyst circulation rate is about 7 tons per minute, which maintains a ratio of 15 pounds of catalyst per pound of oil.

The combined catalyst and oil vapors enter the reactor through a perforated distribution grid located near the bottom of the reactor, and of such size that an annular space is left between the edge of the grid and the walls of the reactor. The catalyst separates into a dense phase above this grid. The vapors passing upward through this dense phase keep it agitated so completely that the bed is at a substantially uniform density.

The oil-catalyst contact time depends upon the weight of catalyst in the reactor rather than the volume, since the density of the catalyst in the dense phase may vary with other operating conditions. A constant weight of catalyst is main-

tained in the reactor by a controller actuating the slide valve at the bottom of the regenerated catalyst standpipe to maintain a constant differential across pressure taps at the top and bottom of the reactor. Thus a constant weight of catalyst is maintained by balancing the catalyst flow into the reactor against that withdrawn.

Most of the catalyst entering the reactor is withdrawn from the dense phase through the annular space around the inlet grid, passing downward into a conical section and thence into the drawoff line or reactor standpipe. Steam is injected at three levels around the conical section in order to strip hydrocarbon vapors from the spent catalyst. About 3000 pounds per hour of steam is used.

Hydrocarbon vapors, steam, and some entrained catalyst pass upward through a disengaging space into a "multiclone" separator mounted in the top of the reactor. The separator is a series of small cyclone dust separators arranged to operate in parallel.

Catalyst knocked out by centrifugal action in the separator is returned to the dense phase through a collection hopper and dip leg. Hydrocarbon vapors carrying only a small amount of catalyst pass overhead from the separator to the fractionator, entering at a point just above the liquid level at the bottom.

The fractionator is an 11- by 65-foot tower containing 12 trays above a center well, and 2 trays, 2 perforated plates, and 7 perforated disc and donut pans below. Heat is recovered from the lower section by circulation of fractionator bottoms through a steam-generating heat exchanger which produces 7000 pounds per hour at 125 pounds pressure.

Oil leaving the steam generator at 400° F. is returned to the fractionator at the upper perforated tray, along with the bottoms stream from the fresh-feed exchanger. This circulation of bottoms not only supplies the necessary cooling, but also provides the liquid wash for scrubbing entrained catalyst from the rising vapors.

The concentration of catalyst in the bottoms or slurry is maintained between 0.5 and 1.0 pound per gallon by continuously returning column bottoms to the reactor via the injector.

Mid-column cooling is provided by circulating sidecut drawn from the center well into an accumulator through a low-pressure-steam-generating heat exchanger which produces about 3000 pounds of 40-pound steam per hour. This stream leaving the exchanger at 300° F. is returned to the column 3 trays above the center well. The sidecut or cycle stock is pumped directly to the thermal-cracking unit.

The fractionator operates at a pressure of 5 pounds. The bottom temperature is held at 550-575° F. and the top temperature is maintained at 225° F. by returning gasoline from a reflux accumulator to the top of the column. Water from the condensation of the steam injected into the reactor is withdrawn continuously from a leg on the reflux accumulator.

Overflow from the accumulator passes through a subcooler into a receiver from which the 400° F.-end-point unstabilized gasoline is pumped to the gas concentration unit, while the gas goes to the compressor suction drum and thence to the first stage of a 600-horsepower 2-stage gas-engine-driven compressor.

Discharge from the first stage at 50 pounds pressure passes through a cooler into a receiver. Low-pressure condensate is pumped to the gas-concentration depropanizer. Fifty-pound gas passes to the second stage of the compressor in which the pressure is raised to 225 pounds. The second-stage discharge passes through a cooler into a high-pressure receiver from which the gas and high-pressure condensate go to the gas-concentration deethanizer.

Spent catalyst leaves the bottom of the reactor at 900-950° F., passes through a slide control valve and drops into the line through which air for regeneration is introduced. The catalyst is picked up by this air stream and carried upward into the regenerator through the regenerator riser, inside diameter of which is 36 inches.

The rate of catalyst circulation is determined from the pressure differential between two points on the riser, and the circulation rate is adjusted by resetting the controller which actuates the spent catalyst slide valve to maintain a constant differential on the riser.

The combined air and catalyst stream passes through a perforated grid into the main section of the regenerator in which the catalyst settles into a dense phase. The temperature in the regenerator is 1050-1100° F. This temperature is maintained by burning coke deposited on the catalyst during cracking. Coke on the spent catalyst amounts to 1.0 to 1.5 percent by weight. This is reduced to 0.5 to 1.0 percent in the regenerator.

The total quantity of coke burned in the regenerator is 30-35 tons per day. Regeneration air is supplied by a turboblower unit capable of delivering 11,600 standard cubic feet at a discharge pressure of 18 pounds. The air rate is controlled by adjusting a butterfly valve in the blower discharge to maintain an oxygen concentration of 2-3 percent in the combustion gases leaving the regenerator.

Combustion gases and some entrained catalyst separate from the dense phase and pass upward through a "multiclone" separator mounted in the top of the regenerator. Catalyst separated by centrifugal action in the separator drops into a hopper from which it is returned to the dense phase through a dip leg. Regenerated catalyst is withdrawn from a hopper in the dense phase passing downward through the standpipe into the reactor to complete the catalyst circuit.

Combustion gases from the regenerator pass overhead at 1000-1050° F., through a waste-heat boiler in which sufficient heat is recovered to generate 3000 pounds of 40-pound steam per hour. The partially cooled gases are further cooled to 375-400° F. by the injection of water into the duct below the waste-heat boiler.

From this duct the gases pass into an electrical precipitator in which the catalyst particles are charged and collected on the plates of plate and frame electrodes across which a high voltage electrical discharge passes. The catalyst recovered from the plates drops into a hopper and passes downward in a small standpipe, through a slide control valve and into an air stream which carries it back to the regenerator.

Combustion gases carrying a small quantity of catalyst fines are released at the top of the precipitator. The total inventory of catalyst in the unit is approximately 125 tons, of which 35 tons is above the grid in the reactor and 55 tons above the regenerator grid. The catalyst replacement on this unit amounts to approximately 1 ton per day.

In order to minimize the use of alloy steel the vessels and lines in service over 1000° F. are internally insulated with 4 inches of soft insulating block and 3 inches of refractory tile.

The catalyst used presently is a synthetic silica-alumina having an average particle size of about 22 mesh.

Gas-Concentration Unit

The function of the gas-concentration unit is to classify and separate the various hydrocarbon fractions contained in the catalytic gasoline, the compressor condensates, the stabilizer overhead condensate, and the high-pressure gases, and distribute them to the best advantage. This involves a number of specific jobs, namely:

1. To recover C_3 and heavier hydrocarbons from the cracking plant gases.
2. To segregate the C_3 fraction for feed to the alkylation or polymerization unit.
3. To segregate the C_4 fraction for alkylation feed.
4. To rerun the 400° F.-end-point catalytically cracked gasoline to 330-340° F. base stock.
5. To segregate the C_6 fraction for aviation-gasoline blending or charging to the alkylation unit.

Catalytically cracked gasoline of 400° F.-end-point, high-pressure catalytic and thermal gas, and high-pressure compressor condensate are charged to the deethanizer.

This is a 4- by 60-foot column containing 28 trays and operating as a combination absorber and stripper. Catalytic naphtha is circulated over the top at the rate of 15-20 gallons per minute, as the absorption medium, and cooling is supplied at the center of the column by circulation of liquid from a reservoir between the 13th and 14th trays, through an intercooler and back into the next tray below at the approximate rate of 50-75 gallons per minute.

The bottom temperature is maintained at 200° F. by an external steam-heated reboiler; top temperature is 100° F. The column is operated at 200 pounds pressure. Ethane and lighter gases are removed overhead and go directly to the fuel-gas system.

The bottoms, consisting of C_3 and heavier hydrocarbons boiling up to 400° F., are charged to the depropanizer which also receives a low pressure condensate from the catalytic cracker and stabilizer overhead condensate from the thermal cracker.

The depropanizer is a 6½- by 53-foot column containing 30 traps and operating at 250 pounds pressure. Top temperature is maintained at 110° F. by refluxing with part of the overhead condensate at the ratio of 4-5:1, and the bottom temperature is held at 280° F., with heat supplied by an external steam-heated reboiler. The propane-propylene overhead fraction may be charged to the polymerization unit, the alkylation unit, or released as a gas to the fuel system. Bottoms

consisting of C_4 and heavier fractions boiling up to 400° F., flow to the debutanizer under system pressure.

The debutanizer is a 6- by 69-foot tower with 28 trays operating at 50-100 pounds pressure. Top temperature is maintained at 130-145° F., by refluxing a part of the overhead condensate at the ratio of 1-2:1; bottom temperature is maintained at 325° F., by an external steam-heated reboiler, using 275-pound steam.

The BB fraction recovered overhead, consisting of isobutane, normal butane, and butylenes, is caustic washed. This fraction is the normal feed of the alkylation unit. The bottoms from this tower, consisting of C_5 and heavier hydrocarbons boiling up to 400° F., flow under system pressure to the rerun column.

The rerun column is 6.5 by 38 feet, with trays, operating at 5 pounds pressure. Top temperature is maintained at 225° F. by refluxing part of the overhead condensate at a ratio of 1-2:1, and bottom temperature is held at 370° F. by means of an external steam-heated reboiler. The overhead is 330-340° F.-end-point debutanized base stock which contains all of the catalytic C_5 fraction.

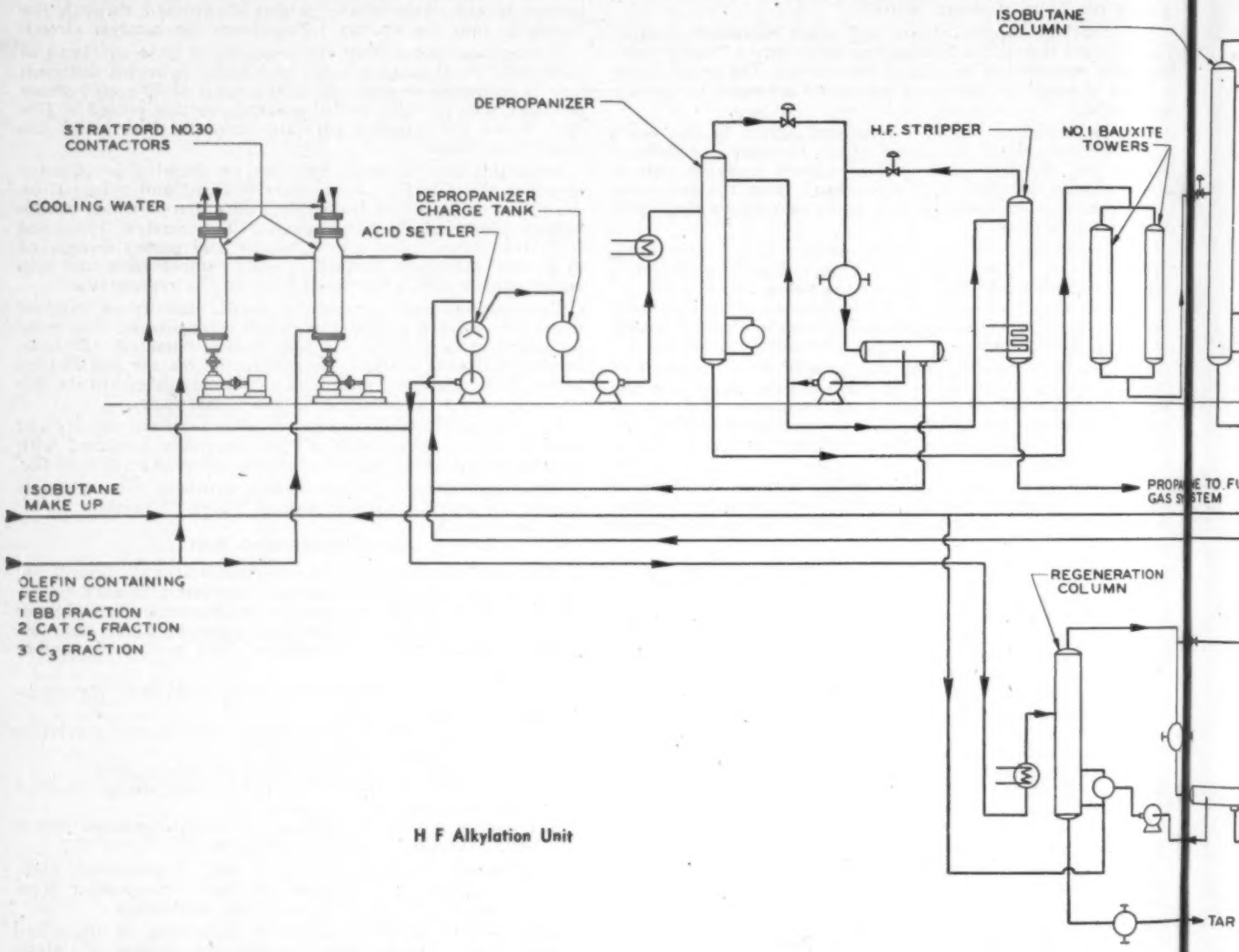
The bottom stream is 300-400° F. catalytic naphtha, part of which is pumped over the top of the deethanizer as absorber oil while the remainder goes to storage, later to be blended with the thermally-cracked and reformed gasoline. The overhead from the rerun column, after passing through a caustic scrubber, enters the dependanizer.

The dependanizer is a column 5 by 76 feet, with 40 trays, operating at 25 pounds pressure. Top temperature is maintained at 140° F. by refluxing part of the overhead condensate at a ratio of 2-3:1. Bottom temperature is held at 250° F. by means of an external steam-heated reboiler.

The overhead is C_5 fraction which goes to storage. The bottom stream is dependanized catalytic base stock which represents about a 20 percent yield on the gasoil-kerosine charge to the cat cracker. The caustic treated base stock is inhibited with UOP inhibitor, either No. 4 or No. 5, blended with alkylate and isopentane, ethylized to make 100-octane gasoline.

HF Alkylation Unit

The hydrofluoric acid alkylation process combines isoparaffins with olefins in the presence of a catalyst to produce alkylate. Isobutane is the isoparaffin employed; butylenes are the olefins used in greatest volume, although propylene and amylenes are also employed. The alkylation process is really the key to 100-octane gasoline yield, because the quantity of alkylate available usually governs the quantity of aviation gasoline that can be made.



H F Alkylation Unit

The fact that the new facilities today are producing 150 percent of the originally estimated output of 100-octane gasoline is largely due to modifications made in the operation of the alkylation unit which made possible utilization of additional C_3 and C_5 fractions as feed stock for alkylation.

Alkylation Feed—Olefins

	Percent
Propylene	2.8
Butylenes	73.4
Amylenes	23.8

The catalyst used in the process is anhydrous hydrogen fluoride which is a liquid under a few pounds pressure. The process is divided into four main sections, as follows: Feed preparation, contacting, fractionation, and acid regeneration.

The olefin-containing feed recovered in the gas-concentration unit is charged from intermediate storage through the feed dryers which are three 2- by 14-foot towers filled with

a desiccant, manifolded to permit the use of two towers while the third is being regenerated. The feed flows directly from the dryers to two contactors.

Volumetric capacity of the contactor is 3100 gallons. Internal circulation is provided by means of an impeller at the bottom of the contactor. The impeller is rotated at 825 revolutions per minute by a 150-horsepower steam turbine operating through a reduction gear.

The contactors are manifolded for parallel flow of the olefin-containing feed, and for series flow of the isobutane recycle and acid, the effluent from No. 1 contactor passing to No. 2. In recent operations it has been found advantageous to dry all or a part of the isobutane recycle by passing it through the dryers along with the BB feed. Thus a part of the isobutane recycle also passes to the contactors in parallel.

The alkylation unit was designed for 6:1 ratio of isobutane to olefin, based on the total feed to the contactor (fresh feed plus isobutane recycle) and the space time was 30 minutes. The throughput has been increased to the point where the yield of alkylate is nearly twice the design production.

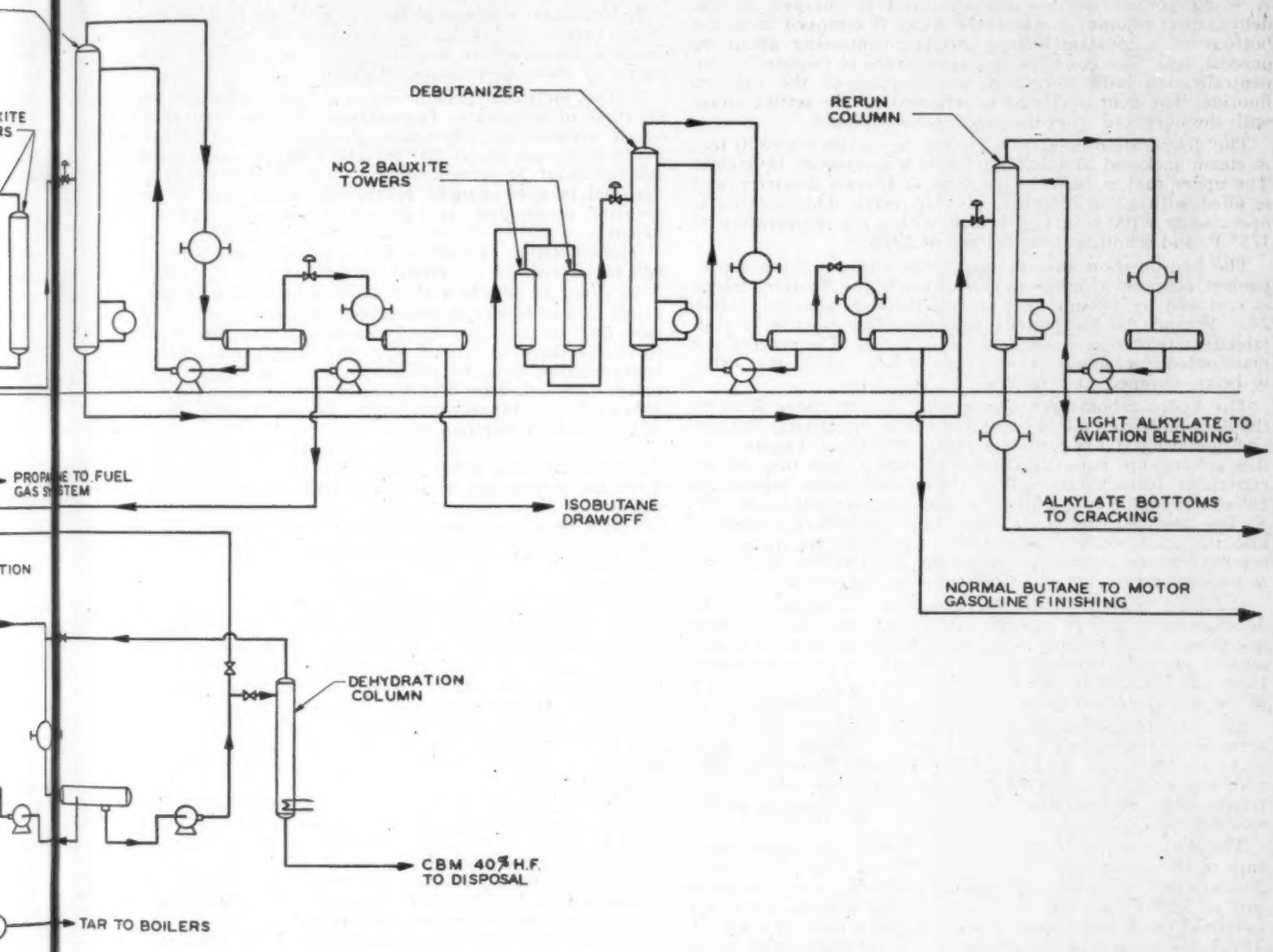
The high throughput has reduced the isobutane-olefin ratio to as low as 3-4:1 and the space time to 15-20 minutes, and has resulted in only slight sacrifice in quality of the alkylate.

Intimate mixing of acid and hydrocarbon takes place in the contactors which operate at a pressure of 85 to 125 pounds. Since heat is generated in the reaction, the contactor is provided with a tube bundle through which water circulates. Temperature in the contactors is maintained at 75-100° F. Space time is 15 to 30 minutes.

From the contactors, the acid-hydrocarbon mixture goes into the acid settler, a horizontal 8- by 30-foot vessel provided with baffles, where it separates into acid and hydrocarbon phases. The hydrocarbon phase is drawn from the top of the settler into the depropanizer charge drum, a 3- by 30-foot vessel. Feed to the depropanizer is pumped from this drum through a preheater in which its temperature is raised to about 180° F.

The depropanizer, a 5- by 40-foot tower with 35 trays, operates at 300 pounds pressure. Top temperature of 125° F. is maintained by refluxing a portion of the overhead condensate at a ratio of 20-30:1, and bottom temperature is held at 240° F. by means of an external steam-heated reboiler.

Because the propane overhead stream contains some free acid, it is pumped to a stripper for separation of propane and acid.



Hydrogen fluoride dissolved in hydrocarbons has an abnormally high volatility; this fact is made use of in the HF stripper which is a 1.5- by 27-foot fractionating column packed with 20 feet of ½-inch carbon Raschig rings. The charge is fed near the top. An internal steam coil at the bottom supplies the heat necessary for stripping—125° F. at the top and 140° F. at the bottom.

A portion of the propane feed, together with all of the free HF, passes overhead into the depropanizer vapor line. The remainder of the propane passes from the bottom of the stripper through a small drum filled with limestone and thence to the fuel-gas system. Acid recovered in this system collects in a leg on the depropanizer receiver from which it is returned to the settler.

One of the primary advantages of the HF alkylation process is the ease with which the concentration of acid in the system is maintained by continuously withdrawing less than 2 percent of the circulating acid for regeneration. This procedure keeps the acidity at the desirable 90-95 percent operating strength; thus avoiding the problems involved in reconcentrating or disposing of large quantities of spent acid.

The small stream for regeneration is withdrawn from the main acid stream circulating from the acid settler to the contactors. Regeneration involves two steps; first, the removal

of any polymer or tar formed in the reaction; second, the removal of water.

The first step is accomplished in the regenerator, which is a 3- by 30-foot tower with 6 side-by-side pans below the feed line and 1 foot of carbon Raschig rings. The tower operates at 90 pounds pressure and at a temperature of 242° F.

The HF is flashed overhead by introducing stripping isobutane through a superheater operated at 360° F. Polymer or tar is withdrawn from the bottom of the column and sent to the boiler fireboxes. The greater part of the acid overhead is returned to the settler along with the stripping isobutane. A small portion of the acid overhead is charged to the dehydration column, in which the water is removed from the bottom as a constant-boiling mixture containing about 40 percent acid. The constant-boiling mixture is disposed of by neutralization with lime and precipitation of the calcium fluoride. The acid overhead is returned to the settler along with the overhead from the regeneration column.

The dehydration column is 25 feet high. The lower 10 feet is steam jacketed and has an inside diameter of 18 inches. The upper part is 14 feet high, with a 14-inch diameter, and is filled with ½-inch carbon Raschig rings. This column is operated at a 100 pounds pressure, with a top temperature of 175° F. and a bottom temperature of 300° F.

The hydrocarbon stream leaving the bottom of the depropanizer contains a small amount of combined fluorides which is removed by passing this stream through bauxite at 200-240° F. and 290-300 pounds pressure. The bauxite is contained in two towers, each 4½ by 25 feet. The towers are manifolded for flow through one tower, while the other is being dumped and refilled.

The hydrocarbon stream from the bauxite tower flows to the deisobutanizer, a 7- by 110-foot tower, containing 50 trays and operating at 100 pounds pressure. Overhead vapors from this column are partially condensed and passed into an accumulator from which reflux is returned to the top of the column at a ratio of 2-2.5:1 to maintain a temperature of 120° F. The net overhead passes through a secondary condenser into the final receiver from which the isobutane recycle is returned to the contactors. A bottom temperature of 250° F. is maintained by an external steam-heated reboiler.

Bottoms from the deisobutanizer are charged to the debutanizer which is a 3- by 47-foot column with 25 trays operating at 80 pounds pressure. Overhead from this column is partially condensed and passed into an accumulator from which reflux is returned at a ratio of 3.5-4:1 to the top of the column to maintain a temperature of 135° F.

The net production passes through a final condenser into a receiver from which normal butane is pumped to storage to be blended later with the cracked and reformed gasoline to bring its vapor pressure up to specifications. The bottom temperature is maintained at 325-350° F. by an external steam-heated reboiler.

The bottoms from the debutanizer flow under system pressure to the rerun column, a 3.5- by 42-foot tower containing 20 trays and operating at 5 pounds pressure. A top temperature of 225° F. is maintained by refluxing with a part of the overhead condensate from the receiver at a ratio of 0.1-0.2:1. The bottom temperature of 350-375° F. is maintained by an external steam-heated reboiler.

The overhead from this column is the finished aviation alkylate fraction having the following characteristics:

Quality of Alkylate Produced

Octane rating A.S.T.M. clear	91.1
AFD 1 C + 4.6 cc TEL	108.0
AFD 3 C + 4.6 cc TEL	8+2.46
90 percent point	238° F.
End point	294° F.
RVP lb.	6.5

This material goes to intermediate storage and subsequently is blended into aviation gasoline. The bottoms from the rerun column amounting to less than 10 percent of the total alkylate, is charged to the catalytic cracking unit for further recovery of material boiling below 330-340° F. and cracking of fractions boiling above 400° F.

The modifications in operating procedure which increased the production of 100-octane gasoline by more than 50 percent over what was expected, consisted in taking full advantage of the flexibility and versatility, not only of the alkylation unit, but of the cat cracker and the gas-concentration system as well.

The operation was changed in several ways, namely:

1. The catalytic cracker was operated to produce more olefins without appreciably reducing the quality of the base stock.

2. The gas concentration depentanizer was changed to an alkylate debutanizer to remove a bottleneck in the alkylation operation.

3. The gas concentration debutanizer was operated as a depentanizer, removing all the BB and C_5 fractions overhead. Thus the catalytic C_5 fractions containing about 30 percent amylenes could be charged to the alkylation unit along with the BB feed.

4. Isobutane is obtained from outside sources where there is an excess over local requirements, to make up the deficiency, inasmuch as it takes 1¼ barrels of isobutane to 1 barrel of olefin to produce alkylate.

5. The increased production of aviation gasoline led to a shortage of isopentane. Isopentane is blended to increase the vapor pressure of 100-octane gasoline. Arrangements were made to obtain about 200 barrels a day of isopentane containing about 30 percent olefins, from another refinery. This material is now charged to the alkylation unit to increase alkylate production and to make up vapor-pressure deficiency.

The alkylation unit still is not overloaded and present plans call for increasing the charge of propylene.

In order to obtain a depropanizer overhead fraction free of all C_3 and lighter hydrocarbons, the low-pressure condensate and thermal overhead condensate are to be charged to the deethanizer instead of to the depropanizer of the gas-concentration unit. Preliminary operation has already indicated that a C_3-free depropanizer overhead fraction rich in propylene can be recovered with no appreciable increase in BB loss in the deethanizer.

The possibility of installing an isomerization unit in conjunction with the other operations was investigated. However, the production of normal butane in the cracking operations is only sufficient to meet vapor-pressure requirements of the motor gasoline and there is not enough casinghead gasoline available to the refinery to make up vapor-pressure specification.

Utilities

The utilities provided in connection with the operations in Plant 3 include three boilers designed to produce 50,000 pounds of steam per hour each, at 275 pounds pressure. A feature which is novel in a western Pennsylvania refinery boiler plant is the use of powdered coal, which combines the advantage of using the cheapest fuel available in the area with the flexibility usually expected only with gas or oil firing. Not only does the boiler plant supply all the steam needed in Plant 3, but also it pipes a considerable quantity to Plant 2.

Another innovation in the area is a 6-section induced draft cooling tower, designed to cool 10,000 gallons a minute from 110° F. to 85° F. at 75° F. wet bulb. Loss of water through the system is only about 5 percent.

Other facilities include an inhibiting system, blending tanks, safety building with first-aid room, time and change house, shop and laboratory for testing products.

Storage for 100-octane gasoline and its components includes:

One 5,000-barrel, 85-pound pressure sphere for storage of alkylate feed stocks.

Two 1000-barrel, 85-pound pressure vertical bullets for isobutane storage.

One 1000-barrel, 85-pound pressure vertical bullet for normal butane storage.

Two 2500-barrel, 25-pound pressure spheroids for catalytic pentane fractions storage.

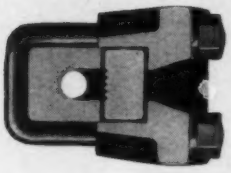
At every stage of planning and construction of this aviation gasoline refinery, the designers and builders, as well as the joint owners were constantly mindful of the need to save every possible pound of critical materials, every possible item of critical equipment.

Every requisition was carefully scrutinized; substitutions were made wherever feasible. Every economy was effected that could be justified from the standpoints of safety and efficient operation.

The plant is considered to be paying good dividends in 100-octane gasoline produced. How about the dividends in lives saved? How many extra blockbusters will crash down on Tokyo to shorten the war? How many American flyers will come safely home because of those thousands of barrels of 100-octane gasoline that four Pennsylvania refiners put up a fortune to produce?

We'll never know.

Alike in Quality



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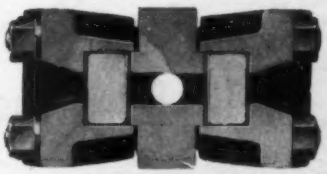

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PENBERTHY PRODUCTS

The Three Catalytic Cracking Units at Baton Rouge Refinery of Standard Oil Company of New Jersey, Louisiana Division. Photograph by Edwin Rosskam.

Baton Rouge Ceremony Delivers Plant's Billionth Gallon Of 100-Octane Fuel to Representative of Army Air Corps

The billionth gallon of 100-octane gasoline produced June 1 at Standard Oil Company of New Jersey's Baton Rouge Refinery was presented to Major James F. Collins, Pacific war hero, by M. W. Boyer, vice president and general manager. Shown here are Lieutenant Max Wilson of Nebraska; Captain Charles Reilly, Baton Rouge; Ray Dobyns, Standard Oil Employes association member; Major Collins; Governor James H. Davis of Louisiana; Boyer; Major General Troy H. Middleton, commander Eighth Army Corps; Captain Charles Speegle, and Lieutenant Sam Houston.

PRODUCTION of a billion gallons of 100-octane aviation motor ful went into the record of the Baton Rouge plant of Standard Oil Company of New Jersey June 1, when the event was celebrated with fitting ceremonies. The symbolic billionth gallon was presented to Major James F. Collins, whose home is in Baton Rouge, by M. W. Boyer, vice president of the company.

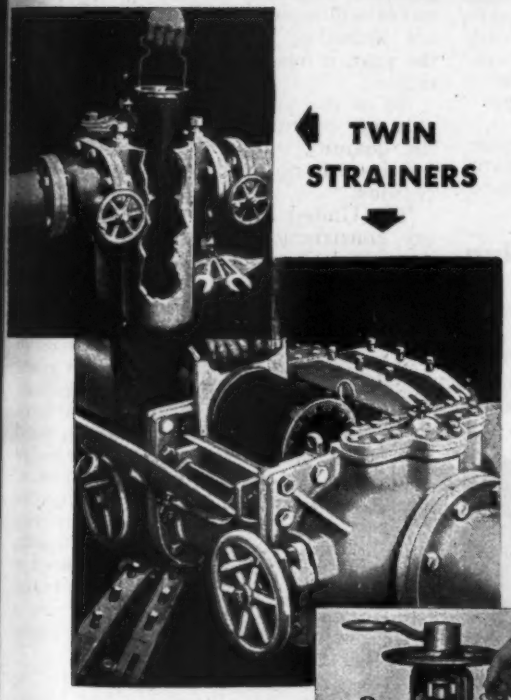
Among the other distinguished military guests at Baton Rouge for the event was General Troy H. Middleton, also of Baton Rouge, who was commandant of cadets at Louisiana State University when Major Collins was a student there. Collins, who is now stationed at Elgin field, Florida, is the holder of both the distinguished service cross and the distinguished flying cross. General Middleton, commander of the Eighth Army Corps, recently was cited by General George S. Patton because of outstanding leadership.

Brief ceremonies at the plant marked the accomplishment of producing a billion gallons of fighting grade aviation gasoline. Previously this had been accomplished by Humble Oil & Refining Company at its Baytown plant and Standard Oil Company of California had

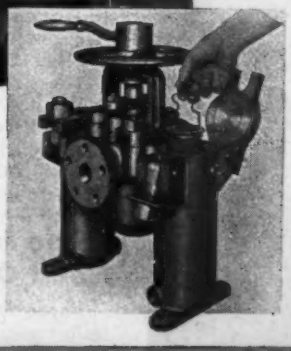
Trouble-that never happens

solid matter in oil, service water, process liquids, cannot get past . . .

ELLIOTT STRAINERS



TWIN STRAINERS



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If you have a condition that requires strainers, discuss it with the Elliott man, and get the equipment that will do the job reliably and with the minimum of maintenance.

TWIN STRAINERS for oil and process liquids. Sizes to 12". Pressures to 300 lb.

TWIN STRAINERS, Type R, usually used for service water. Sizes to 42". Pressures to 150 lb.

TWIN STRAINERS of plug cock type. Handwheel frees plug for easy rotation to put cleared cylinder on the line, then forces plug to a tight fit.

SINGLE STRAINERS for use where conditions permit temporary shutdown for cleaning.

SELF-CLEANING STRAINERS—motor-driven rotating element successively isolates fouled sections which are automatically flushed.

STRAINER BASKETS any required mesh, to fit any of the above strainers.

Bulletin with full details and specifications, at request.

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ELLIOTT STRAINER HEADQUARTERS

announced a similar accomplishment May 31.

In addition to its record in making aviation motor fuel the Baton Rouge plant has been an outstanding contributor to other phases of the war effort. Previous to the fall of Singapore the plant had a unit in operation for the manufacture of butadiene and it had for many months been producing Perbunan (Buna-N) as well as Buna-S chemical rubbers.

Along with production of a billion gallons of 100-octane motor fuel the Baton Rouge plant also contributed substantially to the output of this grade of motor fuel in other plants. Its hydrogenation unit was converted to this activity when the need for this motor fuel became pressing. Codimer from numbers of plants was forwarded to treatment and left Baton Rouge as hydrocodimer, one of the most potent of the anti-knock ingredients used in aviation motor fuel.

The first fluid catalytic cracking unit was completed at Baton Rouge, which has for many years served as a field laboratory for Standard Oil Development Company, which carried this catalytic process into commercial stage. Since then two additional fluid catalytic units have been completed.

The role of this plant in the war program was summed up with this paragraph from a news release by the company:

"Since the entrance of the United States into the war, most of the Baton Rouge refinery's equipment and processes have been turned to the manufacture of products useful in winning the war. Figures recently released in Washington show that one out of every 15 planes used in all theatres of combat have been fueled with high-octane gasoline produced at the Baton Rouge refinery."

Standard of California Produces Its Billionth

Standard of California has become the first western oil company to produce its one billionth gallon of 100-octane gasoline, it was announced May 31 by President H. D. Collier.

One billion gallons of this fuel, it is estimated, would fuel more than 22,000 B-29 Superforts for a trip around the world under average circumstances.

Indicative of the vast strides in production is the fact that just one refinery unit now turns out daily nearly five times the amount of 100-octane Standard produced in the entire year of 1937, when quantity output began.

Wyoming Plant Celebrates War Production Record

"The Rocky Mountain Area contributes substantially to the nation's military gasoline requirements," said M. H. Nolan, refinery superintendent, Sinclair Refining Company, Sinclair, Wyoming, today at a celebration of key refinery workers in recognition of the one millionth barrel of 100-octane gasoline produced at the refinery in Sinclair, Wyoming. Mr. Nolan said: "Operating at maximum capacity and pledged to the total war effort, we are proud to pass the one million barrel mark in the production of 100-octane gasoline here at Sinclair, Wyoming. Speaking for the war workers at this refinery, we pledge our continued effort for the maximum production of war products. The record at this plant is another milestone for war production in the Rocky Mountain Area and a symbol of the industrial importance of this section."

(A picture on page 89 of this issue shows the alkylation unit in the plant at Sinclair, Wyoming, where this record was made.)

General Increasing Cracking Facilities at Torrance

General Petroleum Corporation has let contract to The M. W. Kellogg Company for construction of facilities which will add 13,000 barrels daily to thermal cracking facilities of the refinery at Torrance, California.

Night view of Standard Oil Company of California's 100-octane gasoline plant at Richmond.

District 2 Refineries Increase Navy Fuels

In order to meet Navy requirements for kerosine and distillates, E. J. Bullock, director-in-charge for District 2, PAW, early in May issued a directive to 17 refiners in the district to supply specific amounts of the fuels to 13 other refiners for reprocessing. Procedures for allocations were worked out at a meeting in Chicago between PAW officials and refiners in District 2. In a telegram to refiners Bullock said arrangements for compliance with the new schedule takes precedence over other customer requirements.

It was announced that until the Pacific war is won, the Navy will require at least 50,000 barrels daily of several types of fuel oils from refiners in District 2 who had been supplying about 30,000 barrels daily. Refiners and PAW officials believe the increase for the Navy can be met without further restrictions on civilians.

Foreign Refineries Furnish More War Aviation Fuel

More than 14 percent of the aviation gasoline produced for the Allied air forces will come from foreign refineries, not including Russian, by the end of the year, it has been predicted in Washington.

All of this gasoline will become available for operations in the Pacific, but the quantity output of the foreign refineries may not be disclosed for security reasons.

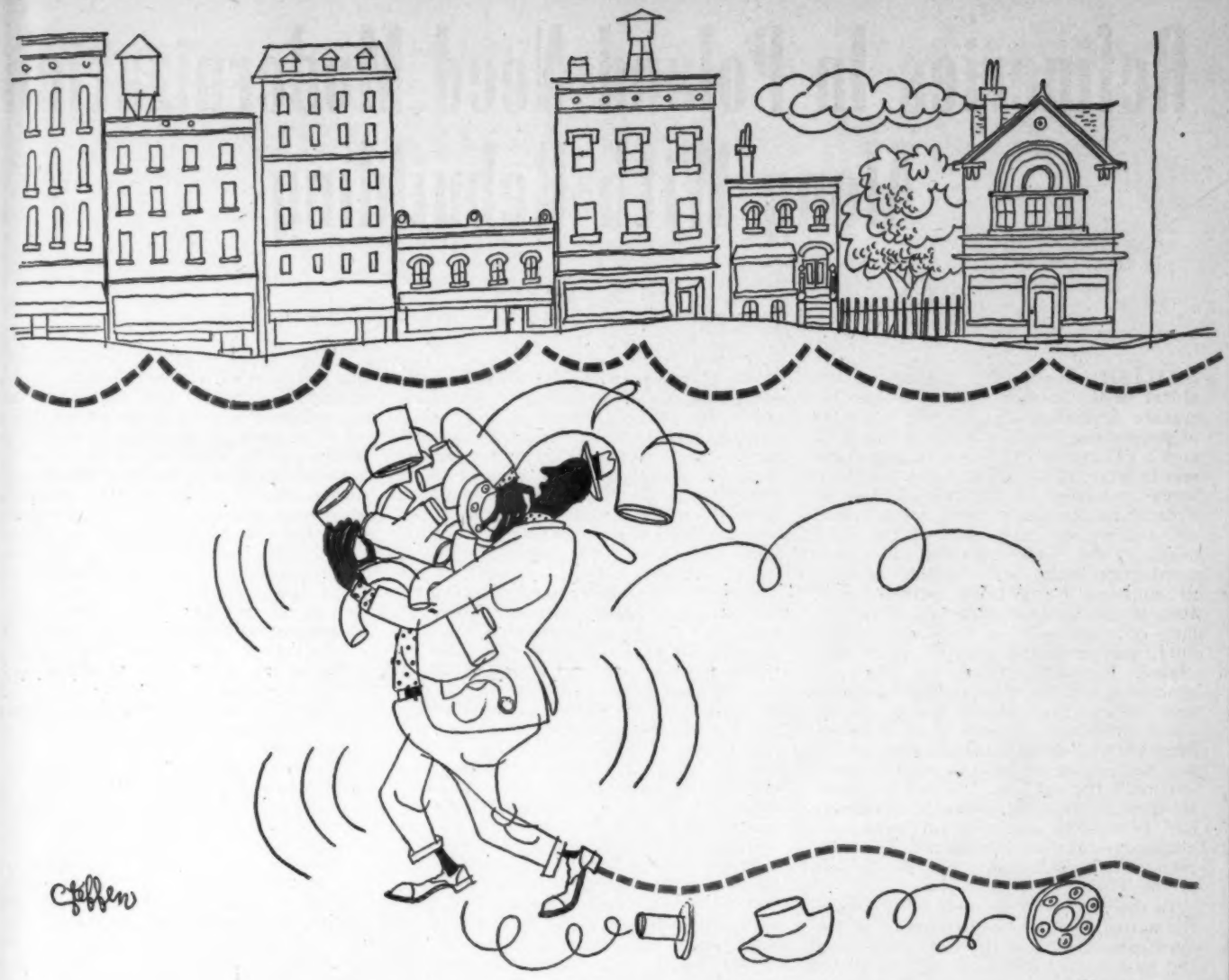
The United Nations' 100-octane refinery construction program is scheduled for completion this year.

Outlining facilities available for 100-octane production, it was said that at the time of Pearl Harbor there were three refineries in the United Kingdom and a fourth at Abadan, with a new plant at Trinidad about to begin production. Since then two expansions have been made to the Abadan refinery and a third will soon go on stream; the Trinidad plant has been placed in full operation; facilities at Bahrein have been expanded to permit 100-octane production; two small plants are operating in Canada; three major projects have been placed in operation at Aruba and four at Curacao. Still remaining to be completed are a fifth project at Curacao and expanded facilities in Mexico.

A large part of the equipment for the plants had to be obtained in the United States. Over-all cost of the foreign program, exclusive of Russia, was in the neighborhood of $200 million, it was estimated.

Three French Refineries Need Only Crude Oil

Three French refineries in the Marseilles area have been so lightly damaged in the war that, with a sufficient crude-oil supply, they could start running immediately with a daily charging capacity of about 39,000 barrels per day, according to members of a French oil commission now visiting the United States. The refineries are Compagnie Francaise de Raffinage, at La Mede; Produits Chimiques et Raffineries de Berre, at Berre, and Societe Generale des Huiles de Petrole at L'Avera.



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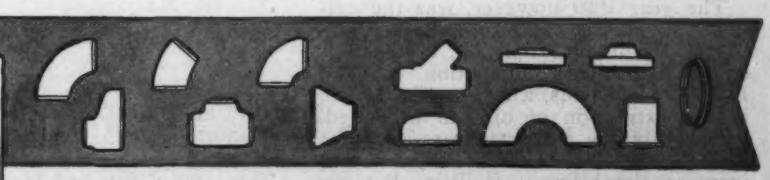

THE COMPLETE LINE OF WELDING FITTINGS AND FLANGES

Refineries In Poland Need Modernization Along With Rebuilding

DAMIAN WANDYCZ
Commercial Counselor, Embassy of Poland, Washington

POLISH oil refineries are among the oldest in the world. Ancient Polish literature first mentions oil and attempts of processing it as far back as the XVI and XVII centuries. The surviving documents from that period speak of privileges extended to certain towns in Poland to illuminate their streets with oil, and in the early part of the XIX century the first commercial export transaction took place — which consisted of shipping barrels of petroleum to Prague for lighting purposes. However, lack of continuity of endeavor in this field was characteristic of this early period. Repeated efforts to obtain or process crude oil were quite short-lived and futile — they would break off because either the deposits of oil were exhausted, and there did not exist, as yet, any knowledge of how to exploit them, and only the oil "ooze" was being utilized; or because the methods of refining and processing available oil were very elementary and unsatisfactory. This time then, may be called the "prehistoric" era of the Polish oil industry.

In the industrial meaning of the word, the actual history of oil refining in Poland commenced in the last 50 years of the past century, concurrently with the oil-extracting industry, which industry has been increasing systematically ever since. The extraction of crude oil steadily increased and developed, and alongside it, the oil refining industry, not however, in as fast a tempo, for oil production began to expand very rapidly towards the end of the last century and the beginning of the present, when the oil fields in Boryslaw and Tustanowice were discovered.

The existing refinery apparatus was not adequate to meet the demands of increased production, thus creating difficulties in the oil industry, and a particularly sharp crisis in this respect developed in 1909, when the production of oil exceeded 2,000,000 tons. Poland then occupied third place, (following the United States and Russia, but preceding Rumania) in the list of world producers. Lack of facilities for processing all of the Polish oil yield in the refineries caused a price crisis on the oil market. In consequence of this, there took place a swift development of the existing refineries, and the erection of the State Refineries in Drohobycz, which were at that time the largest refineries in Europe.

The year 1909 however, was the culmination point for the oil-extraction industry. From that time on, as a result of the so-called "inundation" of the Boryslaw oil fields, a systematic decline in the extraction of oil can be noted. Despite this, in the first years after the first World War there existed a trend to increase the refinery facilities because of the expected increase in the production of oil. However, when the decline in the extraction of oil continued on, in a few years the refinery situation in Poland underwent a complete reversal in comparison to the year 1909: the processing facilities of the refineries proved to be greater than the oil which was available. Since even the amount of domestic oil exceeded the needs of internal consumption, utilization of the refinery apparatus for the additional processing of imported oil could take place only for export purposes. This procedure, however, proved to be non-profitable. Consequently, the Polish refineries, as a whole, were not completely utilized, which naturally increased the cost of processing and in turn resulted in the shutting down of some refineries and the centralization of processing in a smaller number of plants. This retarded new investments in refineries. Since this was a period of new discoveries in the processing methods throughout the world, it affected the Polish refinery industry very seriously, for although up to the First World War the technical standard of the larger refineries was on a par with the world level, and in some branches, such as paraffin-wax it was outstanding, after the war, it was impossible for the Polish refineries to attain this level. If, despite this, its manufactured products were identical in quality to the products of world industry, this should be attributed to the ingenuity and efforts exercised by the refinery technicians.

In the last complete statistical year prior to the present war, 1938, the conditions in the refining industry were as follows:

There were 37 refineries in Poland, out of which there were: 12 larger plants which had a yearly output of over 40,000 tons; 25 medium and small plants which had a yearly output of less than 20,000 tons. The general, theoretical, output of all the refineries was calculated at 1,150,000 tons of oil yearly, out of which the larger refineries' capacity was: 950,000 tons, and the medium and small refineries—200,000 tons. The yearly capacity of the individual large refineries was as follows:

"Polmin"	156,000 tons
"Galicja"	108,000 tons
"Vacuum Oil Co."	108,000 tons
"Limanowa"	96,000 tons
"Trzebinia"	84,000 tons
"Glinik Marjampolski"	78,000 tons
"Jaso"	72,000 tons
"Jedlicze"	60,000 tons
"Fanto"	54,000 tons
"Dros"	42,000 tons
"Nafta"	42,000 tons
"Gazy Ziemne"	42,000 tons

Among the medium and smaller plants only a few had facilities to process from 10,000 to 20,000 tons annually; the remainder were small plants, equipped with obsolete machinery and not adapted to a complete processing of oil. The general capacity of Polish refineries, given above according to a theoretical calculation as 1,150,000 tons annually, should in practice be calculated at several percent lower. This capacity exceeded the oil production in Poland.

In 1938 Polish refineries processed 501,875 tons of crude oil, which constituted approximately the Polish production of oil for that year, and was about 50 percent of the processing capabilities of the refineries. Not all these refineries were active, from the aforementioned 12 larger plants, only 10 were active, (the refineries "Limanowa" and "Fanto" were not functioning). The active refineries processed 467,723 tons of crude oil, which comprised 93.2 percent of the total processing. The medium and small refineries, out of which there were 22 active, processing 34,051 tons, i.e. 6.8 percent of the total processing.

Mention has already been made that the Polish refineries in the period after the First World War were not sufficiently modernized. Actually only a part of the refineries were equipped with modern machinery. Out of the 12 large plants (10 active), only 6 were equipped with pipe stills under atmospheric pressure and vacuum; the remaining plants had shale stills under ordinary pressure and vacuum (usually using the Brunn-Konigsfelder M. F. system). Cracking equipment was installed in only three refineries (in two Cross, in one Wolff-Borsig), which was the result of the existing conditions in the consumption of oil in Poland — low use of gasoline, high use of kerosine, which condition will be discussed further later on. In three refineries there were installations for solvent refining and in two centrifugal solvents for de-waxing lubricants. Almost all were adjusted for manufacturing wax by the method of cold and warm crystallization and sweating, but only two had continuous crystallization in tubes. The rest had crystallizers of the old type.

Apart from this basic refinery equipment, some factories were equipped with special installations for the manufacture of white oils, road asphalts, products from cracking gas, etc. Five had apparatus for the manufacture of greases. A characteristic trait of the work of the Polish refineries was the processing in all refineries of the crude oil into its final product, i.e. asphalt or coke. Fuel oils were manufactured only in small quantities in Poland, due to negligible demand. We manufactured from crude oil such products as gasoline, kerosine, gasoil, paraffin wax and all grades of lubricating oils. Similarly, asphalts were manufactured in ordinary

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grades for roofing materials as well as for road construction. Also, in some refineries side products were manufactured, such as naphthenic acids, sulphur-derivatives, etc.

Normal processing procedure did not adhere to the average procedure of the world oil industry. In the first place, the yield of individual products, obtained from crude oil was as follows for the entire industry in 1938:

Gasoline	19.97 percent
Kerosine	28.16 percent
Gasoil	18.12 percent
Paraffin	4.50 percent
Lubricants	9.40 percent
Asphalt	5.98 percent
Coke	0.78 percent
Others	4.63 percent

The above table reveals, very strikingly, the comparatively low yield of gasoline and wax, and on the other hand, the high yield of kerosine. The following circumstances contributed to this peculiarity in the manner of processing: because of the insufficient electrification in Poland, its rural and small-town population used kerosine lamps for lighting purposes to a very great extent, or almost exclusively, consequently, up to the outbreak of the war, petroleum was one of the most important items of domestic consumption. On the other hand, because motorization was not very well developed, relatively small amounts of gasoline were used. Thus the production of normal gasoline together with gasoline from natural gas exceeded the country's requirements, and for this reason cracking played such a small role in the scheme of processing crude oil in Polish refineries.

In 1938 the production of gasoline from crude oil and natural gas amounted to 141,068 tons, and the consumption to 110,964 tons. Up to 1937 the surplus of gasoline was exported. From 1938, in view of the increasing domestic consumption, export was stopped and the surplus was stored.

Wax Production High

The percentage of obtained wax was high, especially when taking into consideration that it pertains to all of the processed crude oil, and therefore to non-paraffin crude oil as well. Out of the Boryslaw paraffin oil, the amount of wax obtained exceeded 6 percent. This should be attributed not only to the fact that this crude oil was especially rich in paraffin; Polish crude oil was expensive, which forced the refineries to utilize this raw material to the greatest extent. In the world industry, only a part of the wax found in crude oil was extracted. In Poland all of the wax which was obtainable by the existing methods was extracted from crude oil from the low to the high melting point.

Therefore, although Poland's participation in the world crude-oil production was only a fraction of one percent, in the paraffin wax market her share was considerably higher. When in 1928 Poland entered into an international paraffin-wax agreement, her participation in world production amounted to approximately 9 percent. Despite the fact that the Polish paraffin-wax production fell, as a result of the decreasing output of paraffin crude oil, up to the outbreak of the war, paraffin export constituted 50 percent of the whole production.

The year 1938 was considered, in the Polish petroleum industry and especially in the refineries, as a certain turning point. Since many years, for the first time the decrease in crude oil production was halted; renewed activity was visible in the drilling enterprises. At the same time domestic consumption was growing, and the expanding motorization kept opening up new aspects for the increase of gasoline consumption. The export of petroleum products, with the exception of paraffin wax was stopped; despite this, it was evident that in the nearest future Polish production would be found insufficient to cover the needs of the domestic market. The first months of 1939 confirmed this presumption, and in the summer of 1939, in order to meet the demands of the growing consumption, the Polish refinery industry for the first time entered into an agreement with Rumania, importing a part of the crude oil for processing in Polish establishments. In connection with this improvement in the petroleum industry, the last two pre-war years were a period of a partial modernization of refineries, when plans were formed for larger investments. The outbreak of the war interrupted this growth, cancelled automatically all plans, and war operations and the ensuing period of occupation created a new state of affairs.

The refinery industry was thrice within the range of actual warfare: In September, 1939, in 1941 and 1944. Apart from land operations, during the German occupation it was the object of air bombardments by the Allied Air Forces. In 1939 grave damages were suffered by the refineries "Polmin," "Galicia" and "Nafta"—all located in Drohobycz. Partially rebuilt, they again suffered damages in 1941. At this time also the most important installation for the extraction of gasoline from natural gas was destroyed ("Gracja" in Boryslaw).

During the occupation, the refinery industry (as a part of the petroleum industry) underwent the greatest changes as far as the legal-organizational angle is concerned. All petroleum property was confiscated. All rights of ownership were cancelled and after various transitory stages, it was organized into the enterprise established by the Germans, under the title: "Karpathen A.G." in Lwow, which became the exclusive disposer of the entire Polish petroleum industry, and therefore, of Polish refineries also. Refineries located outside of the so-called "general government" area, on territories which Germany considered to be incorporated into the Reich, were excluded from this. There were two such large refineries "Vacuum" and "Trzebinia" as well as one medium-sized one called "Ligota."

Out of the refineries situated in the general government area, the following were active: "Polmin," "Galicja," "Gazy Ziemne," "Glinik Marjampolski," "Jaslo" and "Jedlicze." The refinery "Dros," located nearby, functioned partially as a supplement to the refinery "Polmin." The remaining refineries (amongst others all medium and small ones), were inactive. According to information received, part of them were turned into petroleum storage places, part dismantled for scrap. The active refineries processed Polish crude oil, the production of which fell during the war. As compared to the 507,000 tons obtained in 1938, the production in 1943 decreased by more than 20 percent. The processing scheme underwent a change—production of kerosine fell from 29 percent before the war to 7 or 8 percent. The amounts of gasoline produced did not change. However a special tractor fuel for agricultural tractors was manufactured.

War damages suffered by the refineries were partially repaired. It is known for instance, that the pipe still in the refinery "Polmin" is reconstructed, and the paraffin wax installations were partially rebuilt. The pipe still in the refinery "Galicja" was also not rebuilt and the oil is distilled in old boiler equipment. Certain adaptations presumably were made in the refinery "Jaslo."

Out of the refineries situated in the so-called "incorporated areas" two are functioning: "Trzebinia" and "Vacuum." According to information possessed, they processed crude oil from Austrian, Hungarian and sometimes also oil or residuum from Rumania. These refineries were best equipped. "Vacuum" had modern equipment even before the war, and according to information received, the Germans modernized "Trzebinia" with equipment confiscated by them in other occupied territories.

In 1944, the communiques of the Allied Air Forces confirmed that Polish refineries were bombarded. "Trzebinia," "Vacuum" and "Polmin" suffered serious damages. Whether, and what further damages were inflicted on these refineries during the land campaigns of 1944 is not known at present.

Only a detailed inventory will permit us to make exact calculations of losses suffered by the industry but it appears certain that repeated war activity and the occupation itself reduced its processing capacity to a very great extent in comparison to the prewar period.

Natural Gasoline

In discussing the refinery industry, a few words should be mentioned about gasoline, derived from natural gas. In Poland almost all wet gas was degasolinized. In 1938, in 28 gasoline establishments, 40,000 tons of gasoline were produced. A majority of the establishments were small ones. Of the few larger ones, three possessed equipment for the obtaining and distribution of liquid gas and produced 2300 tons yearly. Most of the smaller gasoline establishments have probably remained intact. We have information that the large gasoline establishment "Gracja" in Boryslaw has been destroyed. The amount of gasoline produced in 1943 was the same as that produced in 1938, i.e. approximately 40,000 tons. This undoubtedly is connected with the German system of exploitation of natural gas, which during the war was obtained from the existing sources in much greater quantities than sound administration of oil sources should permit. However, liquid gas was produced, according to information received, only in small quantities, probably as a result of the damage done to the stabilizer installations.

In connection with the prewar conditions of the Polish refineries, with the situation arising out of the war and the anticipated postwar conditions, certain elements of reconstruction and development are appearing. As has already been mentioned, only an exact inventory of the damages suffered, as well as the definite establishment of the future general economic program of Poland, and in particular that part which pertains to petroleum, will enable us to establish what will have to be done in the given industry.

In considering the problem as a whole,

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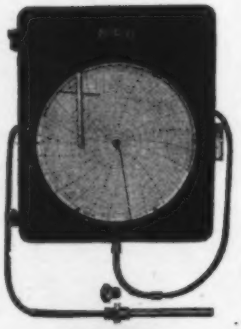

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the following factors should of necessity be taken into account: rebuilding of damages; modernization of the industry, and introduction of new methods of processing discovered during the most recent years. It is of course evident that these factors cannot be treated independently of each other; no one will rebuild installations to their prewar state if that state was at the time obsolete and required modernizing. In other words, the process of rehabilitation will at the same time be a process of modernization in the first stage of the work. Later on of course, modernizing will be extended to the obsolete installations which were not destroyed, as a continuation of plans drawn up before the war. On the other hand, the problem of introducing newly-discovered methods has a somewhat different aspect. Such new methods as polymerization, alkylation and, most of all, catalytic cracking, require for their favorable development large amounts of aviation gasoline. If in Poland after the war the demand for high-octane gasoline is large, then catalytic cracking will be an indispensable item of refinery equipment.

Postwar Development

It is rather difficult to solve this problem at present—it will depend on the economic situation of the country as a whole, and on what the demands of the market at that time will be in quantity and quality. As far as now can be foreseen, in the first few years after the war this new method will be adapted in only a few refineries.

It also will be difficult to estimate just what extent the capacity of the Polish oil refineries should be developed after the war. Polish prewar consumption of petroleum products was very low. There were many symptoms of a swift increase in the consumption of petroleum in prewar times, and undoubtedly the same tendency but even greater will exist after the war, not only later on in connection with the economic development of the country, but in the immediate future—during the period of reconstruction, when automobile transport will play such an important role.

Speaking of the reconstruction and development of oil refineries, it is hard to omit the problem of synthesis of liquid fuel based on natural gas, produced by the Fischer-Tropsch method or its modification.

Poland, as is well known, is a producer of natural gas not only when it accompanies crude oil, but it is extracted from special wells also. In 1938 the yield of natural gas amounted to 584 mil. m.t. and there were possibilities of increasing this production, for the reserves of natural gas were estimated as being considerable. The liquefaction of natural gas can be of interest to Poland after the war. The Germans during the occupation have opened up in Poland a plant for synthesis of liquid fuel from coal. It is not well known what state this factory is in at present after bombardments.

From the above general picture of Polish oil refineries as they were in the past and as they are at present, one could see all the problems of reconstruction and development that this industry will be confronted with after the war.

It devolves from the above, that the role of American industry, as a leader in the building of refineries, will be an important one in the reconstruction of the Polish oil refinery industry.

THE MONTH IN THE INDUSTRY

END of the war in Europe focused attention upon intensifying operations against Japan and laying the foundation for gradual reconversion of industry to peacetime operation. First results of the easier materials situation will be more equipment for oil-field operations, but it has been indicated there will be little increase in quantity of gasoline available for civilians, and no relief of the heating-oil situation.

Runs of crude oil to stills in the United States reached an all-time high during May, when crude-oil storage was held steady only by record rates of production. Refiners charged an average of 4,868,500 barrels daily, or a total of 150,923,500 barrels of crude oil during the month, but gasoline stocks declined to 89,120,000. (See details in table below.)

The big problem now is realignment of transportation to the Pacific.

Russel B. Brown, counsel for Independent Petroleum Association of America, warned a Congressional committee that further tinkering with tariff rates might lay this country open to a flood of foreign oil after the war, and closing of weak wells and inland refineries.

Wendell Berge, assistant attorney general, had opportunity for another blast at "Standard Oil" and its relations with Germany regarding synthetic oil and rubber patents when the Senate inaugurated an investigation of cartels on May 17. Tom C. Clark of Texas has been named attorney general, effective July 1, and it is problematical that Berge will be retained.

Chances that the synthetic rubber plants will be quickly liquidated after the war, as advocated by Henry Wallace, dimmed with statement from official sources that the government-owned plants will be needed for some time after recovery of the natural-rubber areas.

War Emphasis on Fuel Oils Permits Bigger Gas Rations

A 50-percent increase in A gasoline rations and adoption of a nationally uniform ceiling of 650 miles a month for B drivers effective this month is the first relief given civilians from wartime restrictions of three years standing.

Deputy Administrator Davies explained that while the overall oil requirements for the Pacific war will be as great as they were for the two-front war, the emphasis will be more upon fuel oils and less upon gasoline. He warned, however, that the increase is based on the gasoline that will be available while military operations switch from Europe to the Pacific preliminary to an all-out drive upon Japan, and that it might not be possible to continue the higher rations if that campaign develops unforeseen needs for motor fuel.

The raising of the ceiling for B drivers, formerly restricted to 325 miles a month in the East, 400 miles in the Far West and 475 miles in other sections, to 650 miles throughout the country was seen as an indication that the gasoline available for civilians had amounted to more than the 100,000 barrels daily which it was estimated would be needed to hike A rations 50 percent and provide "limited" relief for B card holders. The release is seen in Washington as being probably around 200,000 barrels daily.

"Heavy withdrawals, only part of which can be attributed to seasonal farm needs, have reduced the nation's civilian gasoline stockpile by 4,525,000 barrels since the end of last March," Deputy Administrator Davies said. "While these withdrawals were taken into consideration in releasing the additional gasoline to civilians, it must be recognized that the new program does not anticipate continuance of withdrawals in excess of allocations.

"The refining capacity not only of the United States but of the United Nations, must be operated to capacity to make good the increased civilian ration that has just been announced, and this despite the change in military requirements resulting from the end of the war in Europe. The military demand must always be satisfied first but, this having been done, nothing is being held back from the civilian."

PIWC Wants No Federal Control of Gas Processing

Extending to natural gas the principles of its national oil policy which was laid down in February, 1944, Petroleum Industry War Council following its May meeting released a supplemental policy based on the premise that problems of conservation and waste of oil and gas primarily are industry problems to be solved under state regulation, declaring that "invasion of this field by federal agencies . . . would result in a retardation of technological progress."

The statement admitted that high levels of production and shortage of materials during the war have prevented full application of conservation measures, but contended that these conditions will be corrected upon return of peace.

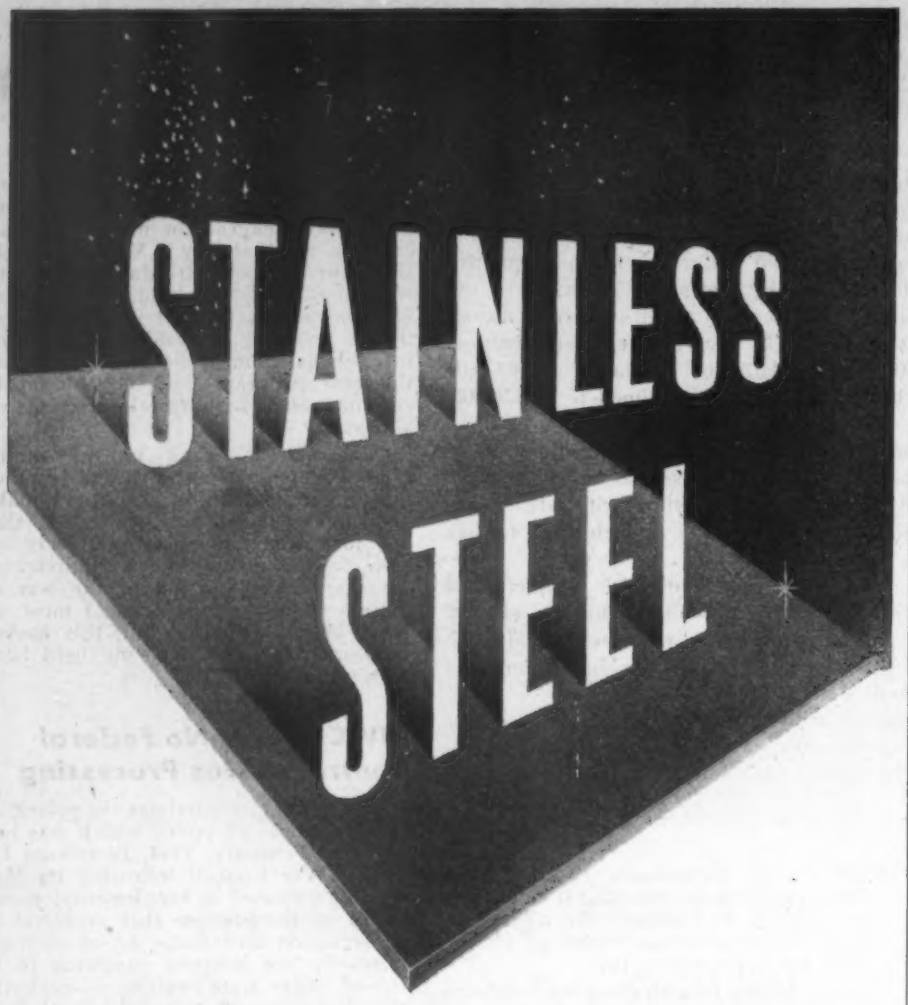
At the same time, while the unsynchronized growth of the oil and gas industries, accentuated by federal regula-

Crude Oil Runs to Stills, Production of Refined Products, and Stocks for the Four-Week Period Ending May 26, 1945

(Figures, in thousands of barrels of 42 U. S. gallons each, on reports of American Petroleum Institute. Production and stocks include reported totals plus estimated amounts to make these figures on a Bureau of Mines basis)

DISTRICT	Capacity Percent Reporting	Crude Runs to Stills: Daily Average	Crude Runs to Stills: Percent Operating	Production: Gasoline*	Production: Kerosine	Production: Gasoil and Dist. Fuel Oil	Production: Residual Fuel Oil	Stocks at Refineries, Terminals and in Pipe Lines: Finished and Unfinished Gasoline	Stocks: Kerosine	Stocks: Gasoil and Dist. Fuel Oil	Stocks: Residual Fuel Oil	Crude Oil: Daily Average Production	Crude Oil: Stocks†
East Coast	99.5	733	92.6	7,447	688	3,546	6,428	13,623	2,722	5,923	5,575	.....	.....
Appalachian District 1	76.8	99	67.5	1,111	233	294	375	2,361	265	344	198	.....	.....
Appalachian District 2	81.2	65	130.0	798	42	167	379	1,504	44	96	136	.....	.....
Illinois, Indiana, Kentucky	87.2	800	93.4	11,594	795	2,860	4,216	21,780	1,288	3,939	1,888	.....	.....
Oklahoma, Kansas, Missouri	78.3	391	83.4	5,700	756	1,823	1,925	9,267	609	1,690	1,146	.....	.....
Inland Texas	59.8	252	76.4	3,971	368	455	1,933	2,932	215	365	823	.....	.....
Texas Gulf Coast	89.3	1,130	93.4	14,799	1,653	5,781	7,457	13,681	1,334	6,135	5,909	.....	.....
Louisiana Gulf Coast	96.8	250	96.2	3,133	827	1,188	1,346	4,463	1,014	1,517	1,429	.....	.....
North Louisiana, Arkansas	55.9	81	64.1	896	191	245	509	2,682	223	714	197	.....	.....
Rocky Mountain District 1	17.1	12	90.4	146	19	30	94	76	20	21	35	.....	.....
Rocky Mountain District 2	72.1	105	66.0	1,514	70	347	896	2,382	101	275	592	.....	.....
California	85.8	931	93.6	9,337	286	2,416	12,579	14,390	411	8,165	20,620	.....	.....
Total U. S. May 26, 1945	85.6	4,849	89.7	60,446	5,928	19,152	38,164	89,121	8,246	29,184	38,548	4,887	221,861‡
Total U. S. April 28, 1945	85.6	4,718	.....	.....	.....	.....	.....	94,068	7,772	28,273	39,813	4,805	223,474
Total U. S. May 27, 1944	.....	.....	.....	.....	.....	.....	.....	86,263	7,744	32,074	50,617	4,514	234,423

* Includes natural gasoline blended at refineries. † Bureau of Mines. ‡ May 19, 1945.



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tion of the latter, has resulted in part o the gas produced as a by-product of oi wells escaping conservation, it was de clared, this fraction has served a useful purpose in oil production and the eco nomic barriers which closed markets to this gas and resulted in its waste are now being lifted.

It called upon producers, however, to hasten development of cycling and re pressuring projects wherever warranted and upon the states to enact legislation or adopt laws to promote such enter prises.

The council held that jurisdiction over production, processing and other activi ties before gas begins interstate move ment should be restricted to state agen cies and that the federal government function only in the realm of interstate commerce.

"The jurisdiction of federal agencies such as the Federal Power Commission should be clearly and rigorously limited to the area of interstate transportation of gas and the sale of gas in interstate com merce for resale," it was declared. "Such agency should not attempt to reach for ward and regulate the local sale or dis tribution of gas, or reach backward and control, either directly or indirectly, the production, gathering, and compressing, or the price of gas prior to its delivery into the main line of an interstate carrier. In the determination of matters affecting the value of gas sold or delivered for interstate transportation, federal regula tion must be required to recognize all reasonable factors which relate to the value of such gas as a commodity at the point of delivery into the interstate transmission line.

"The end use of natural gas should not be regulated, because competition is the best arbiter. No group has the foresight to determine what is the best use of gas. Efforts to interfere with commercial de cisions and to set up artificial standards and barriers will be subject to influence by special groups intent upon special ad vantage. Furthermore, if the state and federal governments enter upon this field of regulation, the ultimate logical end will be a managed economy. This whole field is best left to the determinations set up by relative prices in a free competi tive economy."

The PIWC report has been endorsed by resolution of the American Gas As sociation.

FPC Considers Permit for Liquid Gas Plant Expansion

The Federal Power Commission is ex pected to pass on applications of Hope Natural Gas Company for authority to construct additional facilities in West Virginia to increase capacity of the Hast ings gasoline plant to expand the output of liquefied products

The project is being taken with the support of PAW.

FPC will hold a hearing June 11, at which it also will receive testimony in support of the company's applications for a 100-horsepower gas compressor to be installed at the Cornwell compressor station and gas dehydration plant with a daily capacity of 40 million cubic feet at the Stonewall Jackson compressor station.

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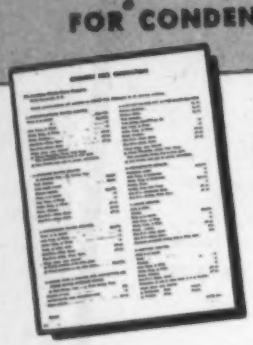

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THE MONTH...

Moving East Texas Cycling Plant to Carthage Area

Lone Star Production Company and Roger Lacy are dismantling their 50,000,000-foot daily capacity cycling plant in the Willow Springs area of Gregg County, in East Texas, for re-erection in the Carthage field, Panola County. The plant was placed in operation late in 1941, but the supply of gas has proven inadequate for economical operation. Gas from the Willow Springs area now is being taken by Lone Star Gas Company.

Humble's Ingleside Plant Seized; More Labor Rumbles

Humble Oil & Refining Company's Ingleside (Corpus Christi; 30,000 barrels) refinery was ordered seized by executive order of President Truman on June 6. The directive to the Petroleum Administrator for War to take over operation of the plant because of "threatened interruption . . . as a result of labor troubles," was said in Washington to have been on advice of the War Mobilization Director, who had his cue from the War Labor Board which has an old feud with the company over the latter's opposition to inserting a maintenance-of-membership clause in a contract with the CIO which runs to May 17, 1946.

Humble Oil & Refining Company officials, who had no intimation of the pending seizure, immediately secured a temporary injunction in federal court restraining Gordon Granger, PAW director of refining for District 3, from seizing the plant. PAW had intimated its "seizure" would be technical, with no interference with plant officials in actual operations.

On the same day, President Truman ordered PAW seizure of The Pure Oil Company's operations in the Cabin Creek, West Virginia, field, where the CIO union had been on strike since May 14, and where maintenance of membership is the issue.

Gulf Refinery Company's big refinery at Port Arthur, Texas, was closed down May 26 for five days by a strike which cost the war effort approximately 1,800,000 barrels of products. Cause of the strike, which was disavowed by union officials, was not clearly revealed either by the workers or the company.

Meanwhile, at Houston a strike at Shell Oil Company's refinery is threatened because of a majority of employes insisting that the company shall not comply with a Fair Employment Practice Committee directive ordering upgrading of Mexican and negro workers.

Sinclair Rubber, Inc., and Goodyear Synthetic Rubber Corporation's operations of their Houston plants were halted several days in the first of June by "anonymous" pickets who obstructed the road to the plants. It was presumed, but no authoritative source would confirm, that the picketing was directed at an open-shop contractor building a plant for Kelly-Springfield Tire Company.

Standard Oil Company of California has been ordered by WLB to disintegrate the employe's association with which it has union-contract relations

REED Quarter-turn Double Disc Gate VALVES

for EASE OF OPERATION LOW MAINTENANCE COSTS

REED VALVES ON GAS TRAP INSTALLATION

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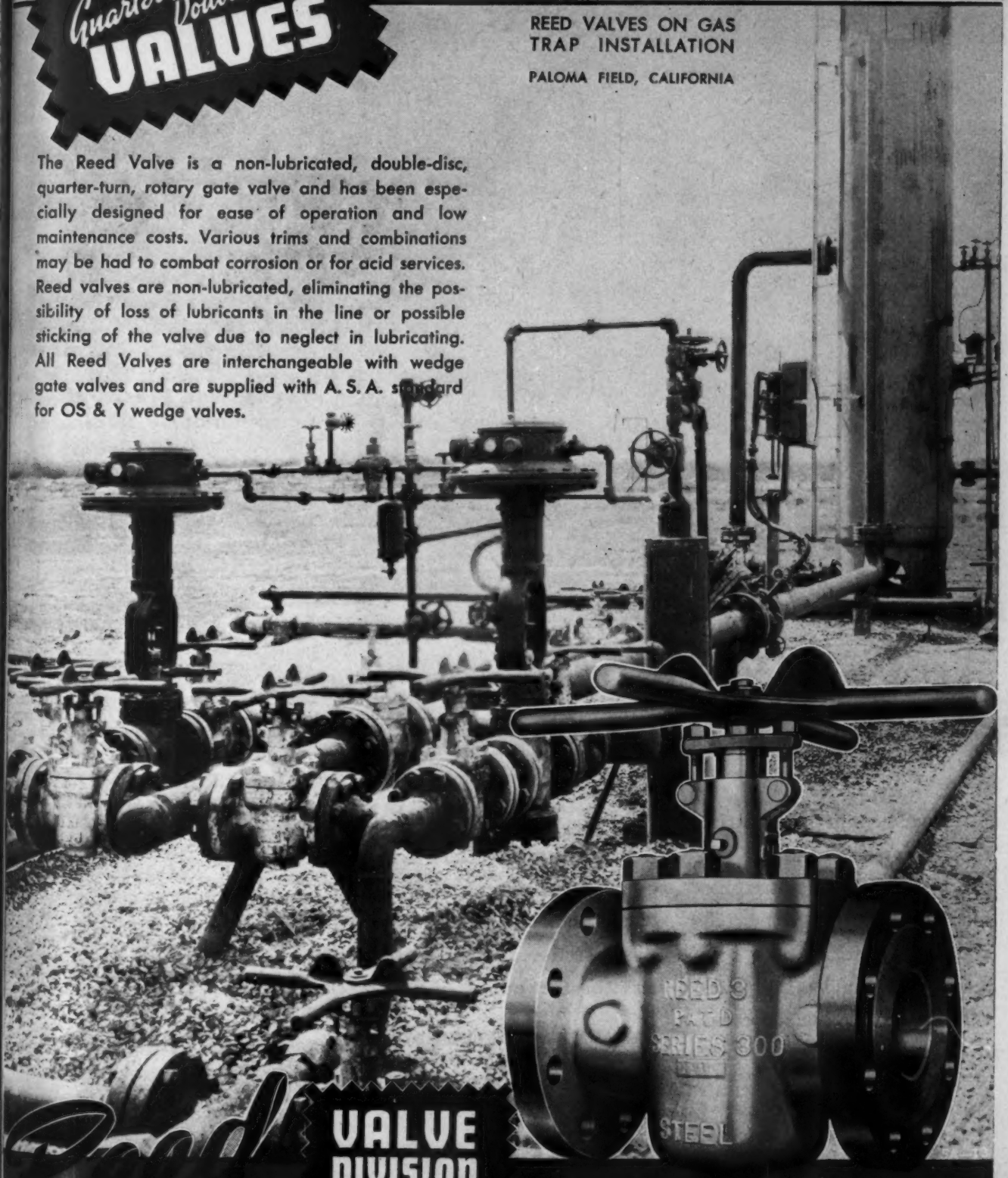
The Reed Valve is a non-lubricated, double-disc, quarter-turn, rotary gate valve and has been especially designed for ease of operation and low maintenance costs. Various trims and combinations may be had to combat corrosion or for acid services. Reed valves are non-lubricated, eliminating the possibility of loss of lubricants in the line or possible sticking of the valve due to neglect in lubricating. All Reed Valves are interchangeable with wedge gate valves and are supplied with A. S. A. standard for OS & Y wedge valves.



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Above is a unit of industrial fabrication essential for the processing of fats and edible oils. This bed spring type coil, consisting of 1300 ft. of 1-¼" seamless tubing, has high ductility. Since it will be subjected to rapid temperature fluctuations (conduit for extremes of live steam and water) it required the character of work that is standard procedure at Associated... Let Associated service serve you!

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ASSOCIATED Progressive PIPING

THE MONTH...

The company has answered that it does not dominate the association, and court action is in prospect.

Humble Oil & Refining Company officials said they were unable to understand the seizure at Ingleside, as there is no stoppage or interruption at the plant. The dispute began May 29, 1943, when the union demanded insertion of the maintenance clause in a contract that then had been approved by the regional WLB office. Later the national WLB overruled the district officials and ordered the company to insert the clause, which it refused to do on the ground that to do so would "force the discharge of any employe who fails to continue his membership." On September 15, 1944, upon intimation that seizure of the plant was pending, the company secured a federal court injunction in advance of the order. This injunction was set aside by the circuit court, which as late as March 1, 1945, denied a rehearing of its ruling, following which the company filed notice of appeal to the Supreme Court.

Haynesville Pressure Plant Ceremoniously Dedicated

Haynesville Operators Committee on June 1 was host at a formal dedication of the recently completed pressure-maintenance plant to serve the Haynesville Pettit Lime oil field, whose 13,620 acres (owned by 1400 royalty owners) lie partly in Louisiana and Arkansas, and are completely unitized. The field currently is producing 6000 barrels of oil and 16 million feet of gas daily, 13 million feet of the gas being returned to the formation, to increase the estimated ultimate recovery of oil by over 6 million barrels, together with 1,600,000 barrels of liquids to be recovered by the extraction plant. Current recovery of the plant is 16,000 gallons of gasoline, 4000 gallons of iso-pentane and 10,000 gallons of butane daily.

Belgian Refineries Mostly Undamaged

Serious bombing damage was suffered by only five smaller refining plants in Belgium during the war. Combined annual prewar throughput of the five plants affected amounted to no more than 14,000 barrels, or approximately 11 percent of the total national refining capacity of 138,000 barrels per year. Belgian authorities report that repairs are being rushed on all damaged plants, and that output will be back to the prewar level by the end of the current year.

Wax Restricted

The War Production Board on June 1 announced that paraffin wax will go under allocation control on July 1 with respect to consumers using more than 20,000 pounds per month. Producers have been requested to submit a proposed shipping schedule for June, and unless otherwise directed will be restricted to that schedule. For shipments after June 30, suppliers are required to file Form WPB-2946 on or before the 15th day of the month before the requested allocation month.

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Sulfuric Acid is aptly named "Industry's Work Horse" for probably no other chemical compound has a greater number of commercial applications. Each of the product's properties leads to a long chain of uses . . . in war . . . in peace.

With Industry's demand for this basic chemical growing constantly, General Chemical Company is now creating new sulfuric acid facilities at strategic locations to help provide for urgent regional requirements.

General Chemical has been one of the nation's important producers of sulfuric acid since the turn of the century when the Company pioneered in America with the Contact Process for manufacturing pure, high strength acid. Today's new developments at Hegewisch, Ill.; Cleveland, Ohio; East St. Louis, Ill., and Newell, Pa. are one more example of *General Chemical Sulfuric Acid serving the nation's needs —now as in the past.*

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THE MONTH . . .

General Electric Plans New Research Laboratory

A new building for the General Electric Company's Research Laboratory, which will afford some 50 percent more space than present facilities provide, will be erected near Schenectady, New York, at a cost of $8,000,000, it has been announced. Construction will begin as soon as WPB approval can be obtained.

The site has been a private estate known as "The Knolls," and includes 219 acres. It is in suburban Niskayuna, 4½ miles from the main plant and offices in Schenectady. Overlooking the Mohawk River, it is on a rocky cliff which will afford solid foundation for the buildings. The river at this point forms part of the New York State Barge Canal, and the Troy branch of the New York Central runs along the bank.

"The two buildings now occupied by the laboratory were built in 1914 and 1922," said Dr. C. G. Suits, vice president and director of research, "and while they were the last word in laboratory construction then, this is no longer true. For some time we have been cramped for space and this condition has been aggravated in the past few years when all our facilities have been devoted to war work. We have a very much expanded program for the postwar years, which will increase our staff from its present 540 to about 800.

"We must look ahead even 15 or 20 years beyond this, when still further expansion may be required. We will probably need to build smaller structures for special purposes, for example, a pilot plant for a new chemical process. All this requires not only a building that is immediately suitable, but one to which we can add and with ample grounds around it for the other buildings.

"Every new and modern feature will be incorporated and I feel confident that we will have one of the finest and most complete research institutions in the world."

The new building, in the general shape of the letter T, will vary from two to five stories in height and will include 200,000 square feet of laboratory working space in addition to an auditorium seating 300, a dining room, conference rooms, etc. One third of the laboratory space will be devoted to service facilities, machine shops and specialty shops such as glass blowers, all in a convenient central location.

Walls between rooms will be movable, capable of being placed at 18-inch intervals so that rooms may easily be made large or small as desired. Benches and all furnishings will be standardized so that they can easily be shifted from place to place as the need arises. The building will be air-conditioned throughout. Wires and pipes carrying various kinds and voltages of electricity, compressed air, suction, illuminating gas, hydrogen, oxygen, etc., will interface the building whence they can be brought into any room.

The high elevation of the site above the river will afford many advantages, for example, in experiments with radar, high frequency jet engines. The rocky cliff foundation will be useful in conducting experiments with X-rays. These are being produced at 100 million volts in the present laboratory, and further increases are expected.

Correction

Due to an error in transcribing the author's manuscript, statement was made in the article "Ceramic Linings for Acid Tanks," by Richard Neuhaus (Refiner, May, 1945, page 120) that resinous cements are suitable for use with nitric acid up to 275° F. As otherwise stated, sulphur-base or silica cements are required where nitric acid is concerned.

Monsanto Chemical Company Announces Two Promotions

Dr. Earl W. Gluesenkamp and Dr. James H. Lum have been appointed assistant directors of research of Monsanto Chemical Company's Central Research Laboratories, Dayton, Ohio.

Dr. Gluesenkamp, formerly group leader in charge of synthetic detergent investigations, was placed in charge of all organic chemistry research groups while the responsibilities of Dr. Lum, director of two war research projects, were extended to include all inorganic chemistry research, physical chemistry research and physics research.

Dr. Gluesenkamp became a group leader at the Central Research Laboratories in 1940, following four years' service as research chemist. He attended

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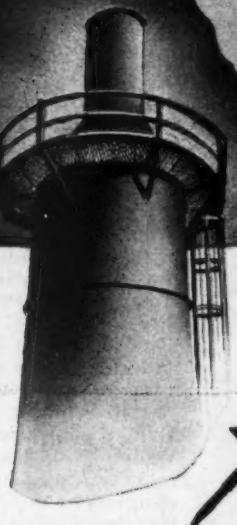

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THE MONTH . . .

Butler University, the University of Illinois and the University of Iowa, receiving his doctor's degree from the last-named institution in 1936.

Dr. Lum started as a research chemist with the Thomas & Hochwalt Laboratories in 1933, and became a group leader when the organization was acquired by Monsanto in 1936. He was appointed project director in 1943. He obtained his doctor's degree at Yale University in 1932, and had previously received a degree from Pennsylvania State College.

Institute Announces Medical Committee

American Petroleum Institute has announced appointment of a medical advisory committee, with Dr. McIver Woody, Standard Oil Company of New Jersey, New York, as chairman, and D. V. Stroop of the institute staff as secretary of the standing committee whose membership includes 17 oil-company doctors and 10 associates from oil-company personnel. Purpose of the committee is to gather and exchange scientific information among medical men in the industry.

Blake Heads Goodrich Chemical Engineering Staff

T. U. Blake has been appointed chief engineer of B. F. Goodrich Chemical Company, to head the engineering staff serving the Geon resin plants at Niagara Falls, New York, Louisville, Kentucky, and Akron, Ohio, at the company-operated government synthetic-rubber plants at Port Neches and Borger, Texas, and Louisville, Kentucky. His headquarters will be in Cleveland.

Previous to his new assignment, Blake was plant engineer at the synthetic-rubber plant at Port Neches. His experience in engineering rubber and chemical manufacturing facilities dates from 1933 when he joined the engineering department of The B. F. Goodrich Company at Akron. Between 1933 and 1942 he worked on many design and construction jobs. In 1942 he was assigned to work on the master designs for the government synthetic-rubber-production program and when that job was completed was made plant engineer at Port Neches.

He was graduated from Cornell in 1928 in mechanical engineering.

F. V. Morrison succeeds Blake as plant engineer at Port Neches. He had been power engineer. He has been with the company since 1942 after graduaiton from University of Iowa.

Robbins Succeeds Parsons As PAW Materials Director

E. E. Robbins has been named to succeed Claude P. Parsons as director of materials for Petroleum Administration for War at Washington.

Robbins was Tulsa sales representative for Oil Well Supply Company when he joined PAW in 1942 as director for materials in District 2. Later he was chief industrial specialist with War Production Board for a period, then returned to PAW as a special assistant deputy administrator. In June, 1944, he left his government connection to join United States Steel Export Company, traveling in South America and Mexico.

Parsons joined PAW in January, 1944, on leave of absence from Halliburton Oil Well Cementing Company, Duncan, Oklahoma, with which he has resumed his post as vice president.

W. H. Collins has been named assistant director of the materials division, succeeding David L. Trax, who will rejoin Gulf Oil Corporation.

Collins, formerly district superintendent for Shell Petroleum Company and general manager of Sharp Deflecting Tool Company, was engaged in business for himself at New Iberia, Louisiana, when he joined PAW in October, 1942.

Trax joined PAW in August, 1943.

Shell Elects Davis Vice President of Manufacturing

C. E. Davis, general manager of the manufacturing department of Shell Oil Company, New York, has been elected a vice president to succeed J. F. M. Taylor, vice president in charge of manufacturing. Mr. Taylor, who is resigning effective June 15, is returning to California to devote more time to his personal interests and some private oil industry consulting work.

Davis has been active during the war years in a number of industry-government committees, including the aviation gasoline advisory committee of the Petroleum Administrator for War, and is now serving as chairman of its catalytic cracking subcommittee. He went to work for the Shell organization in 1917 as a shipping clerk in the company's refinery at Cushing, Oklahoma. In ensuing years he was advanced to other positions at the company'c refineries at Wood River, Arkansas City, East Chicago, and Houston. In 1932 he was transferred to the company's main office at St. Louis in the operations section of the manufacturing department. The following year he became assistant to the manager of that department, and in

C. E. DAVIS

J. F. M. TAYLOR

1938 assistant to the vice president in charge of manufacturing. In 1940 he was made manager of the manufacturing department, and in 1943 general manager of manufacturing.

Taylor, as wartime head of Shell Oil Company's East of the Rockies manufacturing department, has held a position of considerable responsibility and has in addition served on several petroleum industry committtes. He is a member of the District 2 refining committee of the Petroleum Administrator for War, the technical advisory committee of the Petroleum Industry War Council, the general refining committee of the American Petroleum Institute, and a director of the Coordinating Research Council, a joint committee of petroleum and automotive engineers.

Taylor went to work as a trainee at Shell's Wilmington refinery in 1926. He held various supervisory positions at Wilmington, Martinez, and Dominguez refineries, and in 1930 returned to Wilmington as superintendent. In 1932, he was transferred to St. Louis to become manager of the manufacturing department there, and, a year later, was elected vice president. In 1935 he returned to California as president of Shell Development Company, a post which he held until 1943 when he went to New York.

Pure Moves Frank to Toledo, Cooper to Cabin Creek

David S. Frank, superintendent of The Pure Oil Company's refinery at Cabin Creek, West Virginia, has been moved to the company's Toledo, Ohio, plant, where he succeeds Harold L. Smith as superintendent. Smith has been given a leave of absence because of ill health. Clifton W. Cooper, assistant general superintendent at the company's Newark, Ohio, refinery, succeeds Frank at Cabin Creek.

Frank, a chemical engineering graduate of the University of Wisconsin, has been with The Pure Oil Company 14 years, and during much of that time has been

AT CASUAL FIRST GLANCE, the relative values of different refining engineering services are as deceptive as the difference between a custom-tailored suit and its ready-made carbon copy.

From the standpoint of maximum economic advantages and profit possibilities . . . refining managements know that only a *custom* job will put over their postwar remodernization plans. And that is still another reason why the "custom" touch that distinguishes a Kellogg job is so important today.

For instance in catalytic cracking, Kellogg process design evolved its own commercial application of the outstandingly superior *Fluid* process. And in turn, each application of *Fluid* Cat-Cracking by Kellogg is individually altered as required to best meet a client's special needs.

Similarly, Kellogg was first to apply the "Tower" method of propane deasphalting to commercial lube oil production . . . then went on to utilize the process to treat heavy charge-stocks for catalytic-cracking. These Kellogg Pilot-Plant proven innovations in refining pay direct dividends to clients. For example, in a 40,000 bbl. refinery, propane pre-treatment of asphalt bearing reduced crude can mean as much as three-quarters of a million dollars increase in annual operating income.

It is not merely a knowledge of process design that Kellogg relies on to make commercial plants meet production goals. What really counts is what is done with those processes . . . *how and why* they are applied to the individual job.

We think it fair to say that if you will consult the record of Kellogg's "custom" approach to its customers' problems . . . you'll consult Kellogg on your postwar remodernization plans.

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★ **24-HOUR-A-DAY PILOT PLANTS** – 17 refining processes operating continuously–providing accurate data for commercial scale application.

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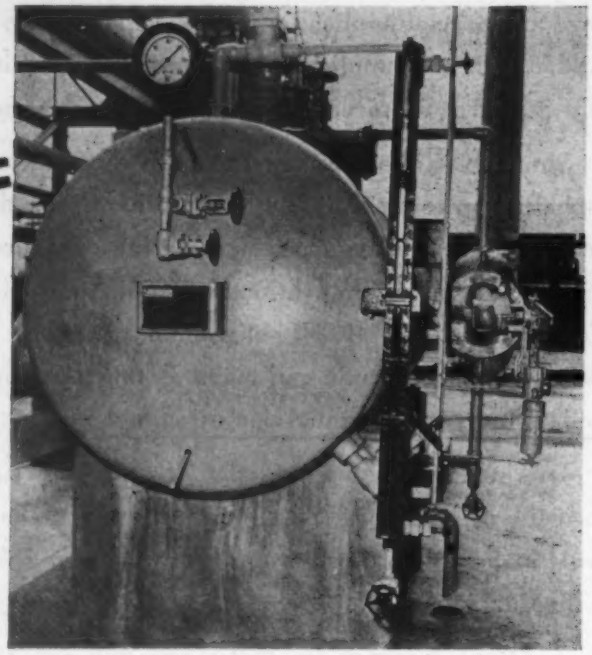

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Durability as well as visibility is needed in liquid level gages for they are subject to destruction from four elements: pressure, temperature, corrosion and external violence.

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d . . . mica-protected glass for use with steam

Standard JERGUSON Gages are designed in Reflex Types for use under pressure up to 3200 pounds at 100° F. or up to 1200 pounds at 1000° F. In the Transparent Type they are designed for pressures up to 2000 pounds at 100° F. and up to 600 pounds at 1000° F. Special gages are available for more severe services. Also jacketed gages.

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6-JV-4

THE MONTH..

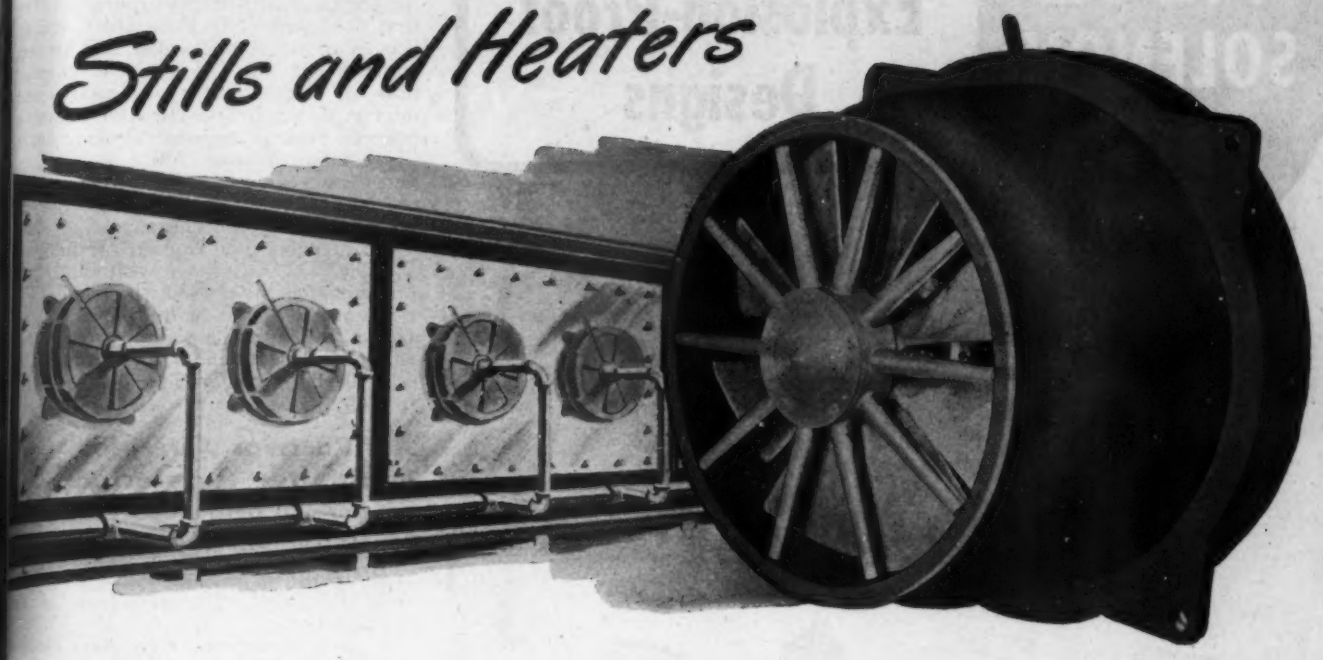
D. S. FRANK

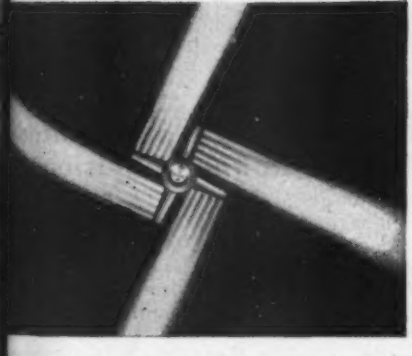
assistant chief combustion engineer o
the refinery control board. He has be
superintendent at Cabin Creek sin
June, 1942. He is a member of the Ame
ican Society of Mechanical Engineers an
American Petroleum Institute, and in th
war effort has been active as a memb
of the War Labor Board for Region

Cooper has been with the compan
since 1933, and at Newark the past fo
years. He received his bachelor of scien
in chemistry at Lawrence College, Appl
ton, Wisconsin. In addition to his petr
leum work in the United States, he wa
in Aruba for two years as corrosion an
materials-testing engineer with Pa

C. W. COOPER

"BUNSEN'S DREAM" UPS THRU-PUT OF *Stills and Heaters*





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The exclusive "pinwheel action" principle of FANMIX produces a perfectly combustible mixture of air and gas that results in:—

1. Complete combustion with less than 5% excess air.
2. Greater heat release.
3. Total absence of drifting "hot spots"

Here's how FANMIX works. Fuel escaping from orifices in rotating driver arms, rotates the fan which draws in air at right angles to the path of the fuel. The energy of the fuel under pressure is utilized to perform work by mechanically mixing and proportioning the fuel with just the required amount of air.

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Coppus engineers FANMIX Burners for individual application. Complete control over rate of combustion or flame pattern can be provided to meet requirements of any installation. Straight gas and combination gas-oil burners available; combination burners burn either oil or gas in entirety or in any proportion. No oil guns needed.

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THE MONTH...

American Petroleum Corporation. His first post with The Pure Oil Company was as an associate chemist, and his next appointment was as resident chemist, first at Heath refinery (Newark) and next at Cabin Creek. He later became a refinery process engineer working out of the company's main office at Chicago, and for a year was assistant general operating foreman at the company's refinery at Nederland, Texas.

Smith, who is a veteran of the First World War, has been with The Pure Oil Company since 1920 when he became resident chemist at Ardmore, Oklahoma. In 1921 he became assistant superintendent at Muskogee refinery, and was in that post until 1930 when he was transferred to Toledo in the same capacity.

API Postwar Activities Committee Is Selected

A Postwar Activities Committee to cooperate in the development of a peacetime program for The American Petroleum Institute, has been named by William R. Boyd, Jr., president of the organization.

Named to the committee were George A. Hill, Jr., chairman; R. H. Colley, H. D. Collier, J. Frank Drake, Bert I. Graves, Eugene Holman, A. Jacobsen, B. Brewster Jennings, W. Alton Jones, Frank Phillips, Charles F. Roeser, Wm. G. Skelly, Reese H. Taylor, A. E. Watts, and Robert E. Wilson.

Parkhurst, Jayne Advanced In PAW Refining Division

Promotion of George L. Parkhurst to contract executive (a new position) of the refining division of Petroleum Administration for War, and of F. M. Jayne to assistant division director in charge of economics and facilities, was announced early in May. Parkhurst has been assistant director of the refining

G. L. PARKHURST

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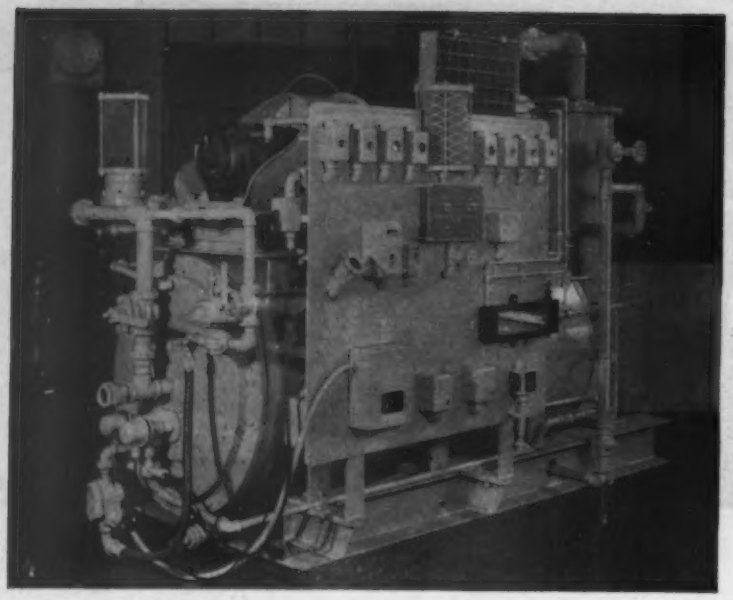

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Available in standard models in capacities ranging from 1,000 to 100,000 CFH **—larger sizes and special models built to order. All** models feature:

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(4) Closely-controlled, high quality INERT-GAS with not over ½ of 1% O_2 or, at operators option, CO.

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KEMP OF BALTIMORE

THE MONTH...

F. M. JAYNE

division, and Jayne has been chief of the economics section of the division.

Parkhurst joined the bureau in December, 1941, as chief of the facilities section of the refining division, and became assistant director in July, 1943. He assisted in arranging for federal assistance and supervised contract negotiations for refineries built to provide aviation fuel during the war period. He graduated as a chemist from Armour Institute of Technology, and later in law from DePaul University, after which he was a patent attorney for Standard Oil Company (Indiana).

Jayne joined PAW in January, 1943, as negotiator of prices, and advanced to chief of the economics section in December of that year. His studies at University of California were interrupted by the first World War, but after an interval in business he returned to that school for a master's degree in business administration in 1934, after which he became head analyst in the manufacturing department of Standard Oil Company of California.

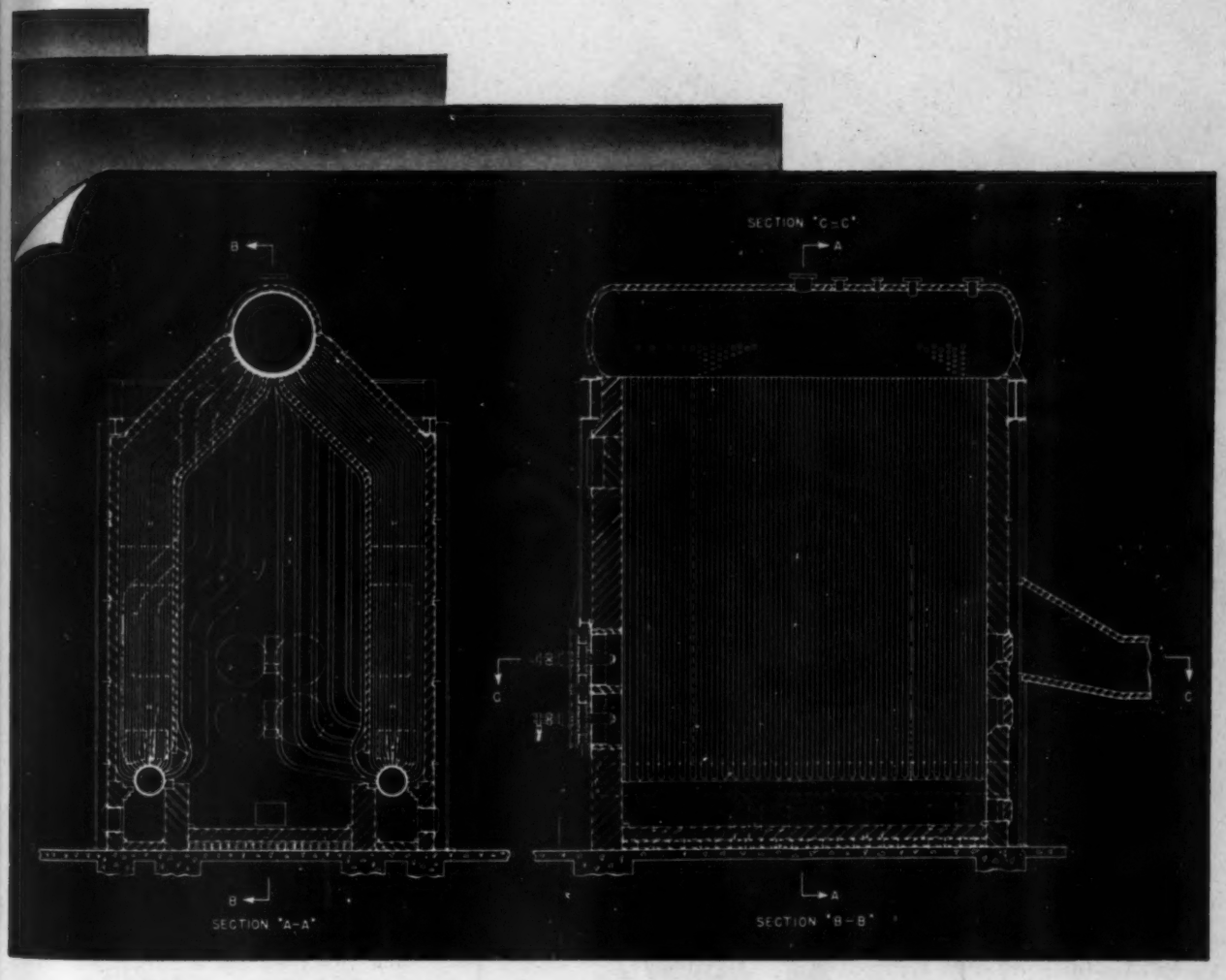
Harris Elected President Universal Oil Products

David W. Harris of Shreveport, Louisiana, recently resigned as president and general manager of Arkansas Natural Gas Corporation, has been elected president of Universal Oil Products Company, Chicago. Thomas W. Bowers of New York, who has been president and chairman of the board, will continue as chairman.

Joseph G. Alther, who long has been associated with Universal Oil Products Company, has resigned as vice president and director. He has agreed, however, to act as a consultant to the company.

McCauley Carter, upon his request, has been relieved of his duties as treasurer and assistant secretary, but is continuing with the company. He has been succeeded as treasurer by Brian R.

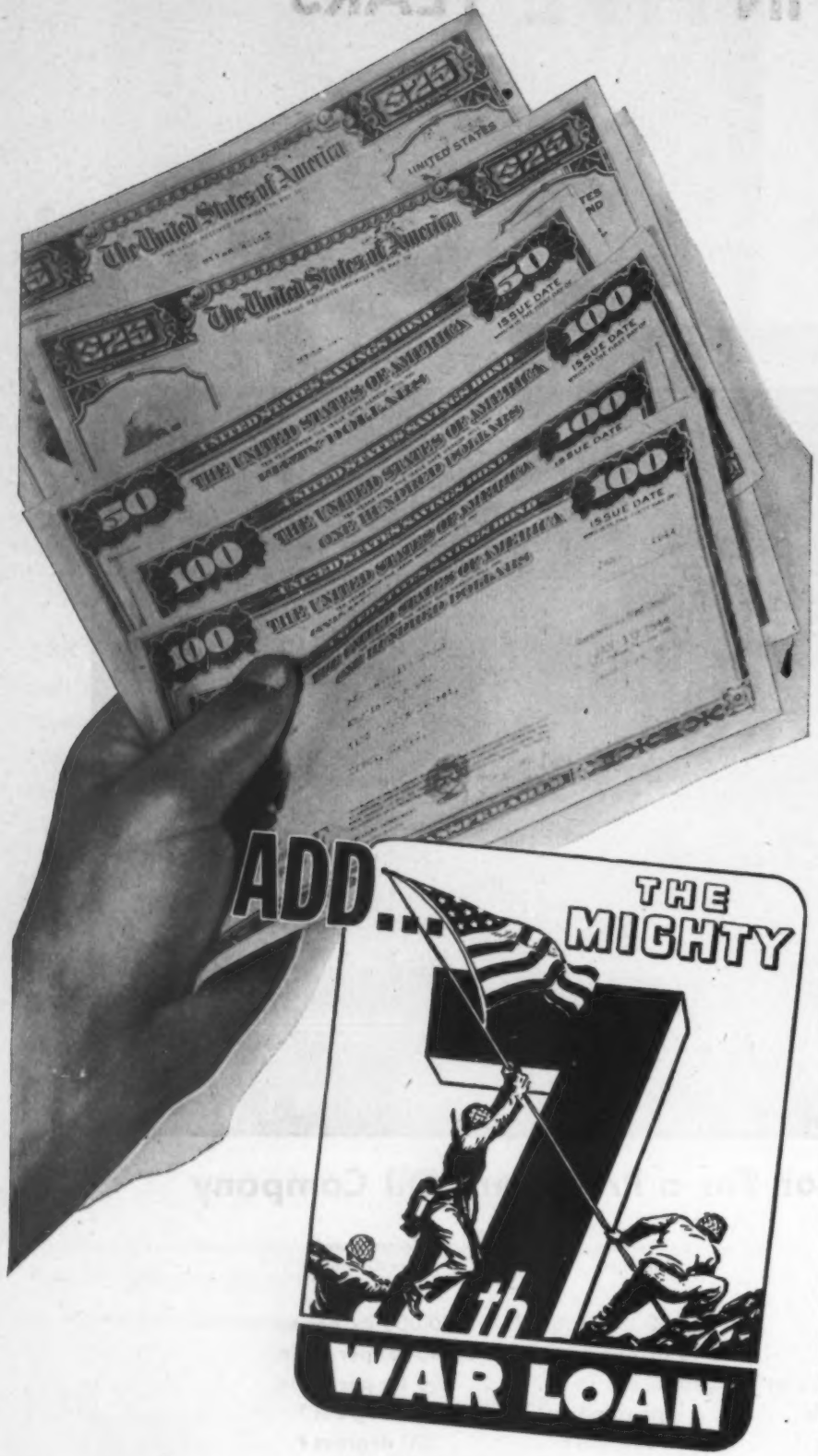
OIL REFINERY IN *FIVE* YEARS



Refinery Installation For a Prominent Oil Company

	Present Operation	*Contemplated Future Operation*
Number of Units	5	9
Steam Capacity	70,000 lb. per hr.	70,000 lb. per hr.
Design Pressure	645 lb. per sq. in.	645 lb. per sq. in.
Pressure: Superheater Outlet	250 lb. per sq. in.	600 lb. per sq. in.
Final Steam Temperature	(Saturated)	750 degrees F.
Feedwater Temperature	225 degrees F.	300 degrees F.
Fuel	Refinery Gas	Refinery Gas
Efficiency	79.1 per cent	83.0 per cent (with air heater)

WHEELER



A War Bond Message Designed and Contributed by Buell Engineering Company, Inc., New York

buell
DUST RECOVERY SYSTEMS

THE MONTH...

D. W. HARRIS

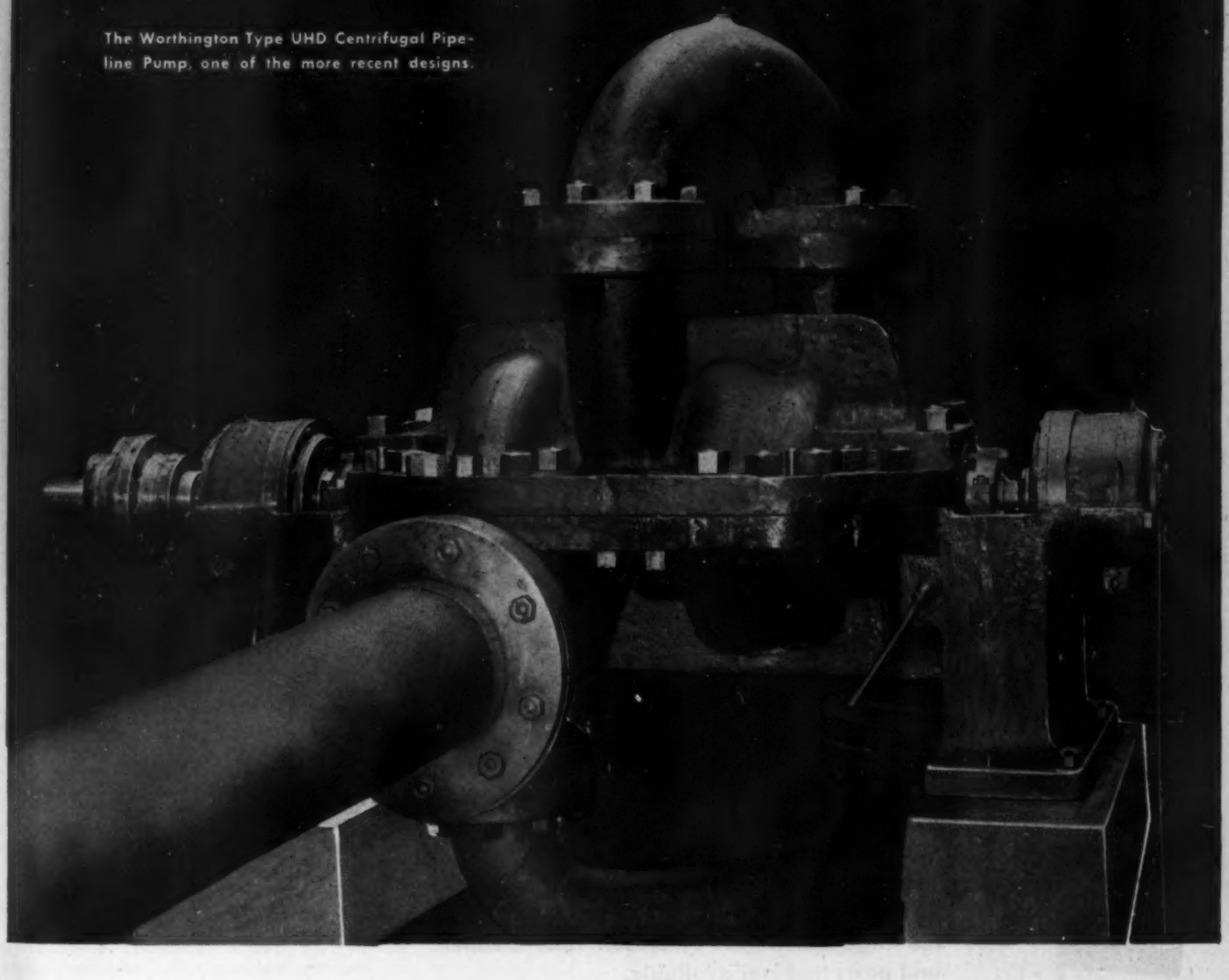
Muirhead, who, until his resignation May 17, was treasurer of Arkansas Natural Gas Corporation, at Shreveport.

Harris, a native of Georgia and son of a former governor of that state, graduated from Georgia School of Technology in 1912, after which he joined the engineering training school of the Doherty (Cities Service) interests in Denver, and after one year was transferred to the general offices of Cities Service Company in New York. During the ensuing 10 years he advanced to director of the budget and assistant treasurer. In 1923 he went to Bartlesville, Oklahoma, as treasurer of Empire Gas and Fuel Company. Later he also became vice president of Indian Territory Illuminating Oil Company. In 1928 he was transferred to Shreveport as general manager and vice president of Arkansas Natural Gas Corporation and its subsidiaries, which included Louisiana Oil Refining Corporation, Arkansas-Louisiana Pipeline Corporation, and others. Subsequently he became president of that group of companies. During recent months he served as vice president and general manager of Cities Service Defense Corporation which built and operated the Maumelle Ordnance Works at Little Rock, Arkansas.

As a member of the technical societies connected with his line of work, Harris has served as councillor of the American Petroleum Institute, vice president and director of Mid-Continent Oil and Gas Association, and director of the American Gas Association.

Harris, as president of Universal Oil Products Company, stated that the purpose of the management will be to continue the general business and policies of the company as in the past. It is intended, however, to further intensify its research, engineering and service activities in order that it may be in position to better serve its licensees under the changed conditions which will

THEY COULD PUMP OIL AROUND the WORLD



The Worthington Type UHD Centrifugal Pipeline Pump, one of the more recent designs.

Worthington originated the first centrifugal pump specifically designed and built for pipeline service..in 1926

Since then, Worthington has built enough centrifugal pipeline pumps to pump oil in a single pipeline *all around the world.* It can be fairly said that Worthington now offers you more pipeline pumping experience than any other pump manufacturer.

What does this mean to you?

By specifying these Worthington Pumps you will get more because . . . mechanical features which provide rugged construction . . . the best wearing materials . . . outstanding hydraulic design . . . are built into Worthington pumps.

Write today for complete facts on Worthington's new Centrifugal Pipeline pumps – or telephone our nearest district office. *Worthington Pump and Machinery Corporation, Centrifugal Pump Division, Harrison, N. J.*

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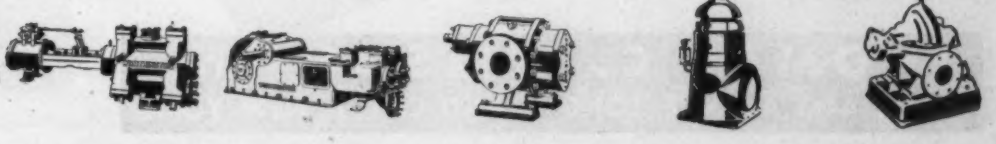

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THE MONTH...

be met with in the postwar period, it was said.

Universal Oil Products Company late in 1944 was placed under a trust agreement for the benefit of the American Chemical Society. This trust is administered by Guaranty Trust Company of New York, and proceeds of the trust are used by the society for its petroleum research fund. Donors of the trust—a free gift of the stock of the company, were Standard Oil Company (New Jersey), Standard Oil Company of California, Standard Oil Company (Indiana), The Texas Company, Shell Oil Company and M. V. de Bataafsche Petroleum Maatschappij.

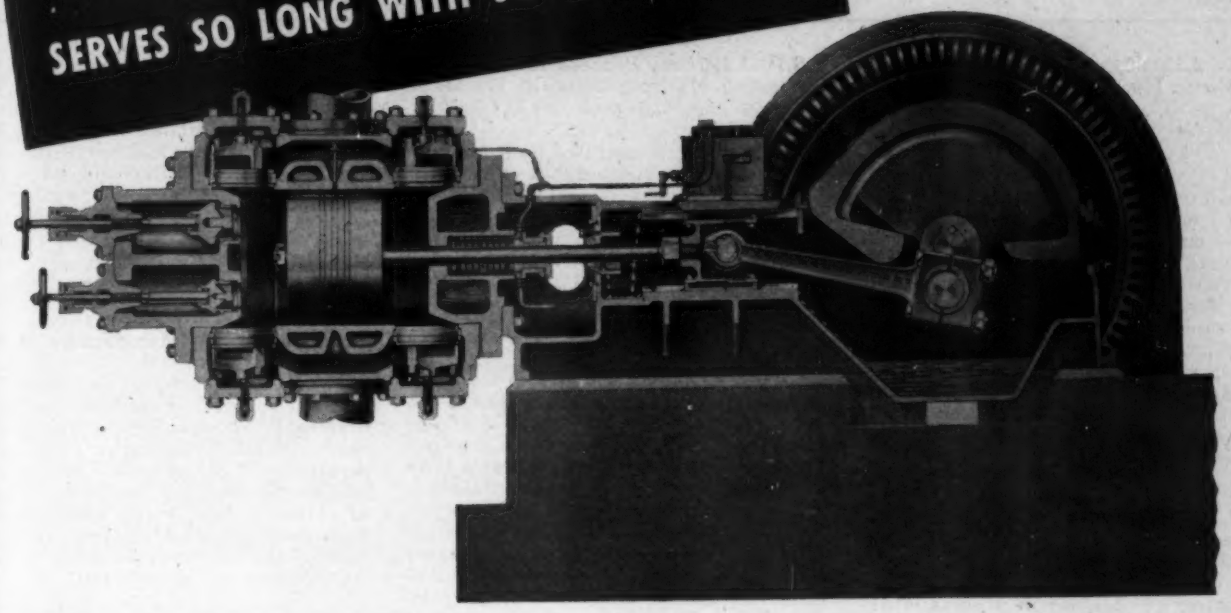
Noll Heads Project Analysis for Houdry

Henry D. Noll has been named manager of the project analysis department of Houdry Process Corporation, Wilmington, Delaware. Noll has had nearly 20 years experience in plant operation, technical service and petroleum research and development. Following graduation as a petroleum engineer at University of Pittsburgh, he was with Magnolia Petroleum Company at Beaumont 9 years, after which he was transferred to the research and development laboratories of Socony-Vacuum Oil Company at Paulsboro, New Jersey. Just prior to his new connection he was on special assignments with the manufacturing department of Socony-Vacuum Oil Company in New York. He is a member of the catalytic cracking subcommittee of the aviation gasoline advisory committee.

W. E. Vogler has been appointed director of industrial relations and personnel for Houdry Process Corporation. He comes to this post from Purdue University where he developed an industrial relations program. Prior to that he was for 12 years personnel manager for Socony-Vacuum Oil Company in upper New York and New England.

HENRY D. NOLL

NO OTHER REFRIGERATION COMPRESSOR SERVES SO LONG WITH SO LITTLE CARE...



because WORTHINGTON *knows* PETROLEUM REFRIGERATION

It's no accident that the petroleum industry uses so much Worthington refrigeration equipment . . . probably more than all other makes put together. It's because Worthington knows exactly what's needed and builds equipment that does the job.

So when Worthington designs Horizontal Double-Acting Electric-Driven Refrigeration Compressors, you expect and get such trouble-saving features as these:

CYLINDERS of special alloyed semi-steel exactly matching the pressure and service requirements . . . with generous water jackets and large clean-out openings.

STUFFING BOXES especially designed for refrigeration service . . . with an auxiliary stuffing box to prevent refrigerant loss when compressor is shut down.

LUBRICATION adequate for full protection of all moving parts . . . full pressure type in large sizes . . . flood type in smaller sizes.

REFRIGERANT PASSAGES generously proportioned for minimum gas friction and lower power consumption.

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Only Worthington Compressors have them . . . the simplest, lightest, most reliable valves ever developed for compressor work. Light strips of flexible steel seat tightly against a ground-face surface. Their easy flexing allows them to lift against the curved guard to permit free passage of refrigerant vapor through the openings in the seat. And they close with gradually increasing contact instead of destructive impact.

Bulletin C-1100-B20, giving the whole story about Worthington Horizontal, Double-Acting Electric-Driven Refrigerant Compressors proves that *there's more worth in Worthington*. You'll want a free copy for your files. Write today to *Worthington Pump and Machinery Corporation, Harrison, N. J.*

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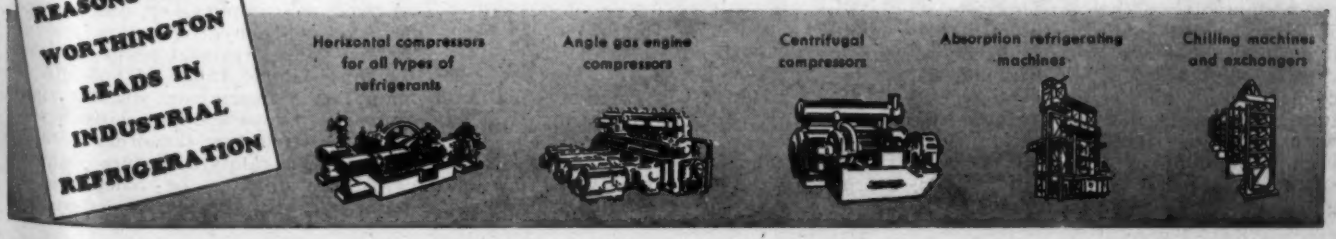
WORTHINGTON

AS.20

FIVE MORE REASONS WHY WORTHINGTON LEADS IN INDUSTRIAL REFRIGERATION


Horizontal compressors for all types of refrigerants
Angle gas engine compressors
Centrifugal compressors
Absorption refrigerating machines
Chilling machines and exchangers

DIGEST OF UNITED STATES PATENTS

On Hydrogenation of Hydrocarbons

Compiled by HEINZ HEINEMANN

U.S.P. 2,330,804. Dehydrogenation of Aliphatic Hydrocarbons. R. G. Atkinson to The Shamrock Oil & Gas Corporation.

Gaseous or vaporous hydrocarbons are passed through a conversion chamber containing phosphomolybdic acid distributed on a suitable carrier while heating the gas passing over the catalyst to a temperature somewhere between 1100 and 1200° F., at which temperature and under which conditions the reaction proceeds rapidly enough so that the hydrocarbon gas or vapor may be processed at a space velocity per hour of about 500-700, yielding a conversion so great that there will be about 10 percent of the corresponding unsaturated hydrocarbons in the exit gas.

U.S.P. 2,332,924. Hydrocarbon Conversion. R. F. Marschner to Standard Oil Company (Indiana).

A combination dehydrogenation, polymerization and alkylation process is described.

U.S.P. 2,335,488. Process for Carrying Out Catalytic Reactions in the Gas Phase. R. Conrad to The Alien Property Custodian.

In catalytic gas-phase dehydrogenation reactions at 500-600° C., a satisfactory rate of conversion can be maintained throughout the reaction zone by moving the catalyst through the reaction zone and raising the temperature in the direction of the movement of the catalyst in such a manner that the rate of conversion does not decrease substantially along the reaction zone.

U.S.P. 2,335,550. Dehydrogenation of Hydrocarbons. J. F. Sturgeon to Universal Oil Products Company.

Aliphatic hydrocarbons are dehydrogenated in the presence of a catalyst which is formed by mixing hydrogels containing at least one component having a dehydrogenating catalytic activity in a partially dehydrated condition, filtering therefrom mechanically removable water, freezing and then thawing the hydrogel composite to destroy its gelatinous structure, filtering and washing the resultant material to remove water-soluble impurities, and drying, forming and calcining to produce an active catalyst.

U.S.P. 2,335,691. Method of Preparing Diolefins. H. O. Mottern to Jasco, Inc.

Conjugated diolefins are prepared by a process involving the condensation of aliphatic mono-olefins with formaldehyde in the presence of an acid-reacting catalyst of between 10-85 percent acid concentration, diluting the reaction mixture containing the condensate with water until the acid concentration has been brought below 5 percent and then steam distilling to recover the conjugated diene.

U.S.P. 2,336,054. Process for Dehydrogenating Hydrocarbons. R. G. Atkinson to The Shamrock Oil & Gas Corporation.

The yield of unsaturated hydrocarbons obtained when hydrocarbons are thermally decomposed is increased by (1) forming a stream of hydrocarbons substantially free of hydrogen, (2) adding an organic acid derivative of tin (e.g. tin naphthanate) and (3) subjecting the stream carrying the catalyst to a temperature sufficient to cause thermal decomposition.

U.S.P. 2,337,191. Dehydrogenation Process. B. S. Greenfelder and R. C. Archibald to Shell Development Company.

Hydroaromatic hydrocarbons are dehydrogenated with a catalyst comprising chromium oxide and about 2.5 -20 percent of a rare earth and 6 -30 percent of an element selected from the group consisting of sodium plus potassium, potassium, rubidium, and cerium, the percentages being based upon the amount of chromium in the catalyst.

U.S.P. 2,341,995. Process for the Dehydrogenation of Liquid and Gaseous Petroleum Hydrocarbons. H. B. Kipper.

Hydrocarbons are dehydrogenated by subjecting them to the action of oxygen and an inert gas at temperatures of 125-400° C. and at superatmospheric pressure in the presence of a catalyst prepared by the fusion of a mixture of at least one metal selected from the group consisting of copper, iron, nickel, cobalt, silver, tin, lead, mercury, molybdenum, tungsten and vanadium with at least one oxide of the same group.

U.S.P. 2,342,383. Conversion of Hydrocarbons. K. D. Uitti to Universal Oil Products Company.

A combination process is described which involves separating n-butane from iso-butane and propane. Iso-butane and propane are thermally dehydrogenated with good yields of iso-butylene and propylene while thermal treatment of n-butane would result in the excessive production of light gases. Catalytic dehydrogenation of n-butane, however, gives satisfactory yields of butylenes.

U.S.P. 2,342,980. Catalytic Dehydrogenation of Isopropylbenzene. H. M. Stanley and F. E. Salt to The Distillers Company, Ltd.

Isopropylbenzene in admixture with water vapor is passed over an oxide of vanadium at a temperature between 500-700° C. The presence of steam prolongs the period of useful activity of the catalyst between revivifications.

U.S.P. 2,343,108. Production of Butadiene. O. W. Cass to E. I. du Pont de Nemours & Company.

Butane is subjected to pyrolysis to produce a mixture of butylene and hydrogen together with some unreacted butane. This mixture is passed into contact with a liquid bromine and water mixture at 20-30° C. and in the absence of light. The butane and hydrogen do not react, the butylene gives dibrombutane. This is separated and subjected to pyrolysis at 450-500° C. giving butadiene and hydrogen bromide. The hydrogen bromide is oxidized with air over a copper catalyst at 200-400° C. to bromine and water.

U.S.P. 2,343,712. Manufacture of Diolefins. R. F. Ruthruff.

Mono-olefinic charge is diluted with hydrogen and the mixture is passed, preferably at superatmospheric pressure over a suitable catalyst at elevated temperatures. High conversion to conjugated diolefin is obtained and the production of carbon is low. From 1-10 volumes of hydrogen are used and the total pressure of the mixture should be less than 200 pounds per square inch.

U.S.P. 2,344,330. Conversion of Hydrocarbons. J. F. Sturgeon to Universal Oil Products Company.

A process for the treatment of a hydrocarbon containing six C atoms in ring arrangement to produce aromatic hydrocarbons therefrom is claimed which comprises subjecting said hydrocarbon to contact with a catalyst prepared by forming mixed metal oxide hydrogels containing at least one component having a dehydrogenating catalytic activity in a partially dehydrated condition, filtering the hydrogels to separate mechanically removable water, freezing and then thawing the filtered hydrogel to destroy its gelatinous structure, filtering, drying and washing to remove water-soluble impurities, forming into particles and calcining to produce an active catalyst.

U.S.P. 2,345,751. Production of Diolefine Hydrocarbons. V. N. Ipatieff to Universal Oil Products Company.

A process to produce diolefinic hydrocarbon from isopropyl alcohol is described which comprises subjecting said alcohol to contact with a magnesium oxide catalyst at a temperature of from 400-500° C.

U.S.P. 2,346,657. Treatment of Butane. H. S. Bloch and R. E. Schaad to Universal Oil Products Company.

N-butane is convered to a substanial degree into i-butene and n-butene by passage through chambers containing a mixture of granules, or other shaped particles, of dehydrogenation and isomerization catalysts at temperatures in the approximate range of 900-1100° F. under atmospheric or slightly superatmospheric pressure for relatively short times of contact in the order of 0.01-5 seconds. The catalyst mixture comprises essentially alumina or bauxite, clays, kieselguhr, etc., supporting chromia and

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a synthetically prepared composite mass of silica and zirconia.

U.S.P. 2,347,256. Process for Converting Hydrocarbons. F. E. Frey to Phillips Petroleum Company.

In a process for the dehydrogenation of a paraffinic hydrocarbon having at least two C atoms per mol to form unsaturated hydrocarbons and free hydrogen, the improvement is claimed which comprises subjecting the effluent from such a dehydrogenation process to the action of a reducible metal oxide at a temperature not higher than approximately 650° F., to react free hydrogen with said metal oxide and formwater, in the presence of an added material adapted to inhibit any substantial action as a hydrogenation catalyst of the metal which is formed in such reaction.

U.S.P. 2,350,485. Method of Preparing Diolefins. E. Arundale and L. A. Mikeska to Jasco, Inc.

Olefins, substituted derivatives thereof, or compounds capable of yielding olefins under reaction conditions, are condensed with aldehydes under such conditions that the condensation product is immediately dehydrated. Catalysts effective in promoting the reactions can be mineral acids (HCl, H_2SO_4, H_3PO_4, etc.), mineral acid-acting salts ($FeCl_3$, $ALCL_3$, $ZnCl_2$, $NaHSO_4$) or organic acids (formic, oxalic, aromatic sulfonic, etc.).

U.S.P. 2,350,628. Catalytic Dehydrogenation Process. M. P. Matuszak to Phillips Petroleum Company.

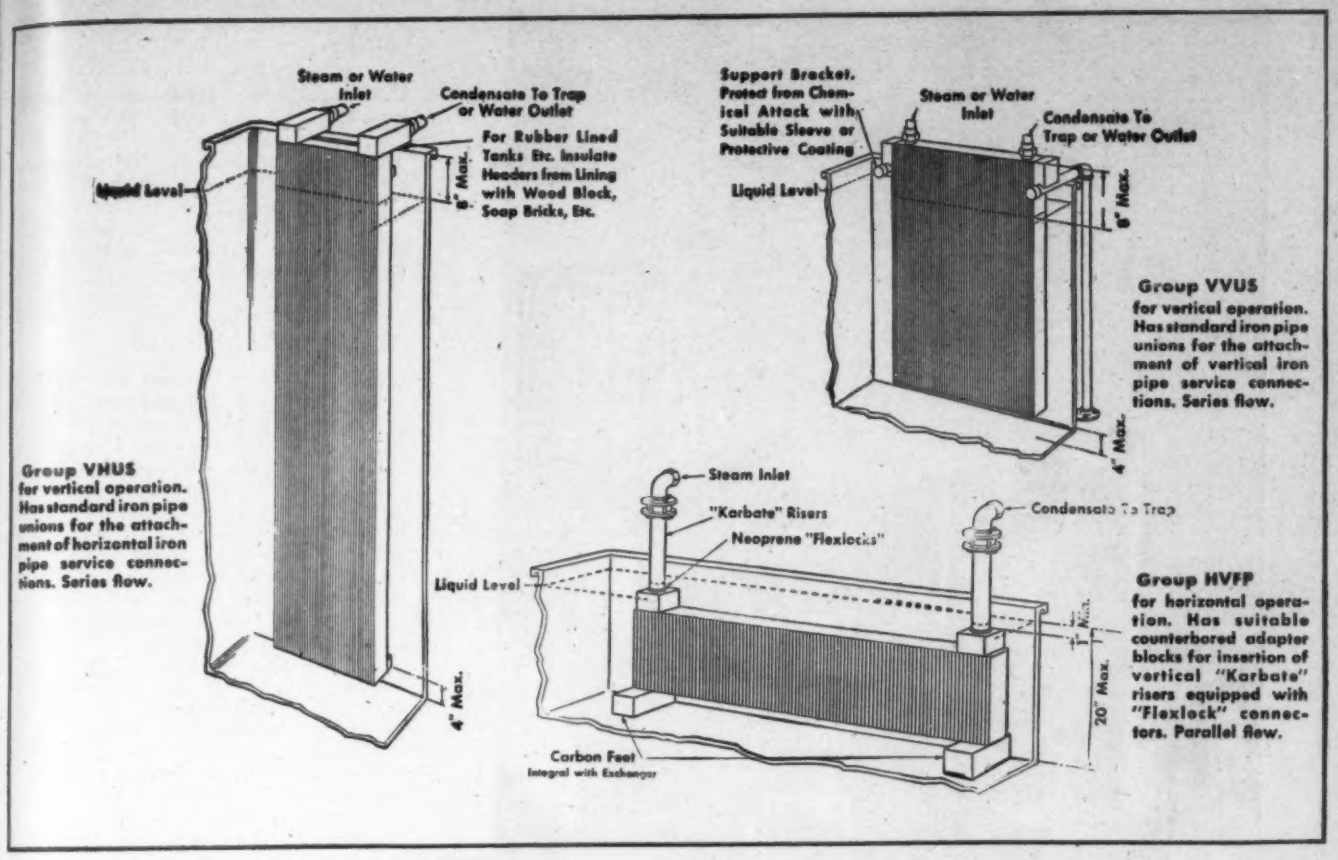
A mixture of two or more paraffinic hydrocarbons is separated into fractions differentiated by some difference in properties such as a difference in the carbon skeleton structure of the hydrocarbon molecule. The fractions are separately subjected to a catalytic dehydrogenation that converts the paraffins to olefins. The resultant olefins are mixed in substantially the same proportions as those that existed for the corresponding paraffins in the original mixture. The steps are carried out under conditions favoring an equal extent of conversion in each step.

U.S.P. 2,353,624. Treating Hydrocarbon Fluids. R. F. Ruthruff.

A combination dehydrogenation and cracking process is described in which a catalyst is employed which comprises a heavy metallic chromite selected from the group consisting of lead zinc chromite, copper barium chromite and nickel barium chromite.

U.S.P. 2,354,892. Dehydrogenation of Hydrocarbons. C. M. Thacker to The Pure Oil Company.

Dehydrogenation of low-boiling saturated hydrocarbon gases can be effected by using a catalyst containing a difficulty reducible metallic oxide gel, which possesses extended surfaces and a highly absorptive capacity for gas and a metal oxide or compound which in combination with the gel imparts thereto the selective property of dehydrogenating hydrocarbons. The catalyst is preferably prepared by mixing salt solutions of the desired metals with activated alumina, heating and drying. The dry catalyst is contacted with air at a high temperature and finally reduced with hydrogen. Tungsten oxide and alumina are a pre-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Liquid Level
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Condensate To Trap
Liquid Level
20" Max.
Carbon Feet
Integral with Exchanger
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You'll say:

Resistance to strong corrosive chemicals.
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Convenient mountings and connections.

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PRODUCTS OF FILTROL RESEARCH AND DEVELOPMENT

ferred mixture and are calcined at 300-800° C.

U.S.P. 2,357,691. Hydrocarbon Conversion. R. F. Ruthruff to Process Management Company.

Catalysts of superior dehydrogenating activity may be prepared under conditions wherein the precipitated gel, prior to drying, is intimately contacted with an aqueous solution in which the negative ions, aside from the hydroxyl ion, essentially consist of ions selected from the group consisting of sulfate ions, carbonate ions, and acetate ions.

U.S.P. 2,360,689. Process for the Dehydrogenation of Gaseous and Liquid Petroleum Hydrocarbons. H. B. Kipper.

In a process for the fabrication of synthetic drying oils the step is claimed of subjecting petroleum oils to oxygen and an inert gas at superatmospheric temperature and pressure in the presence of a metallic element and the oxide of a metallic element, the metallic element and the metal oxide being chosen from the group of metallic elements with commonly known higher and lower oxides and consisting of copper, iron, nickel, cobalt, silver, tin, bismuth, antimony, cadmium, chromium, manganese, lead, mercury, molybdenum, tungsten and vanadium and their oxides and finally the step of heating for establishment of reaction the said unsaturated dehydrogenated petroleum hydrocarbons with a polyhydric organic alcohol containing not over three hydroxyl groups, an oil-soluble natural resin and a vegetable drying oil condensed with the said resin.

U.S.P. 2,361,008. Process for the Treatment of Hydrocarbons. E. Buddrus and H. L. Hays to Phillips Petroleum Company.

A combination desulfurization and dehydrogenation process is described, the dehydrogenation step of which is carried out in the presence of a suitable catalyst such as chromium oxide gel, chromic oxide carried on a suitable porous support, or bauxite under pressure and temperature conditions of the order of 0-100 pounds and 600-1200° F., respectively. Conditions are maintained such that not more than 30 percent of the charge stock is converted per pass.

U.S.P. 2,361,044. Production of Stilbene. W. J. Mattox to Universal Oil Products Company.

Dibenzyl is dehydrogenated to stilbene with a catalyst comprising alumina and an oxide of an element selected from the group consisting of vanadium, chromium and tungsten. Yields of 20-50 percent of stilbene may be obtained per pass. Temperatures in the range of 450-700° C. and pressures of 0.1-35 atmosphere are employed.

U.S.P. 2,362,218. Process for the Dehydrogenation of Hydrocarbons. W. A. Schulze and J. C. Hillyer to Phillips Petroleum Company.

N-butane is dehydrogenated under suitable conditions to produce a mixture comprising butadiene, butene-1, butene-2 and butane which is passed over an isomerization catalyst under conditions suitable to promote the conversion of butene-1 to butene-2. The effluent is fractionated to produce an overhead boiling lower than trans butene-2, and bottoms comprising essentially cis- and trans-butene-2. The overhead is recycled to dehydrogenation after absorption of bu-

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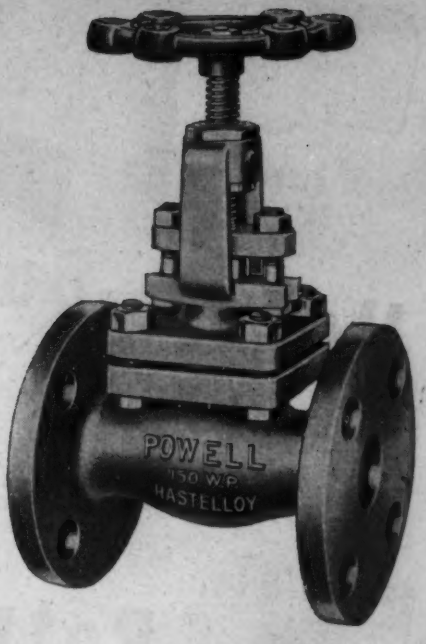

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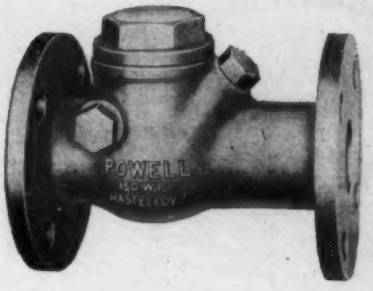

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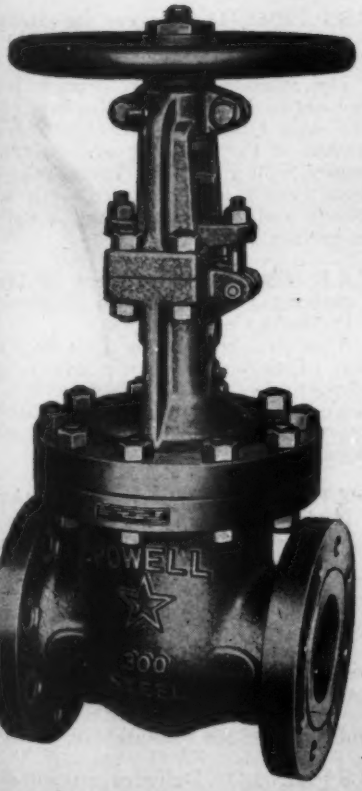

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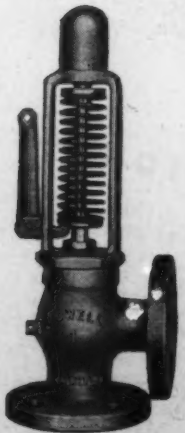

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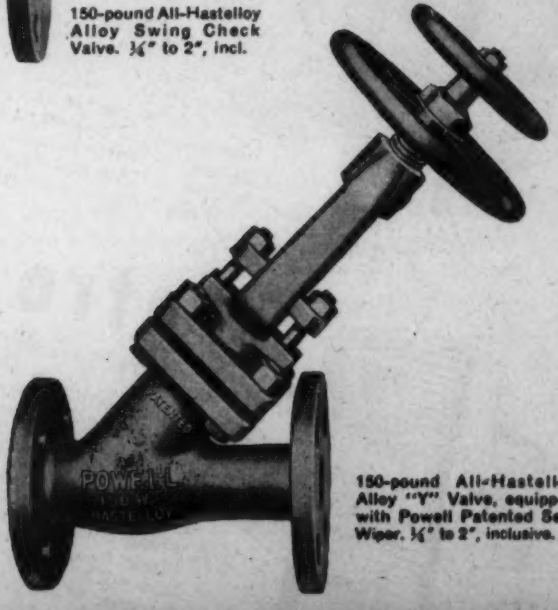

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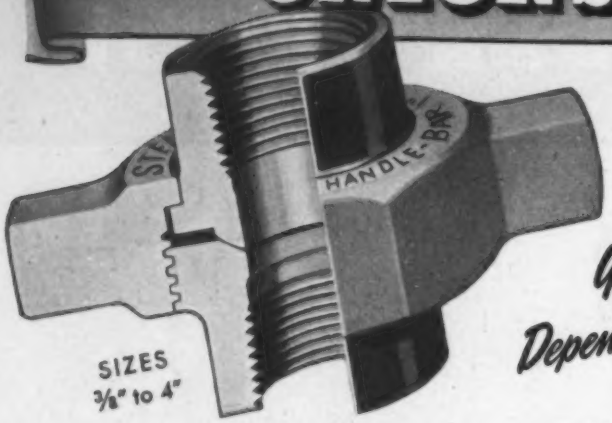

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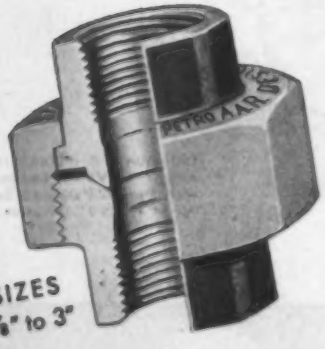

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tadiene therefrom and the bottoms fraction is treated in a second dehydrogenation step to convert a substantial portion of the butene-2 to butadiene.

U.S.P. 2,363,187. Treatment of Hydrocarbons. E. T. Laying to Process Management Company.

The preparation of a catalyst suitable for dehydrogenation reactions is described. It contains as an active ingredient chromic oxide formed by heating an oxygen compound of chromium capable of thermally decomposing to a residue comprising chromic oxide and a flux comprising an oxygen compound of boron. The mixture of compounds of chromium and boron is fused, heated to decompose the chromium compound to chromic oxide and washed to remove boron compounds.

U.S.P. 2,363,824. Process of Treating Hydrocarbons. I. L. Wolk to Phillips Petroleum Company.

The dehydrogenation of paraffins, preferably normal paraffins, or olefins or mixtures of paraffins and olefins to the corresponding olefins and diolefins or mixtures thereof may be advantageously carried out using as a catalyst bauxite which has been previously employed for the isomerization of olefins, and preferably of n-olefins to iso-olefins. Isomerization as a side reaction during dehydrogenation is thus avoided.

U.S.P. 2,365,413. Process for Dehydrogenation of Gaseous and Liquid Hydrocarbons. H. B. Kipper.

The dehydrogenation process is carried out in a nitrogen atmosphere at 350-800° and atmospheric pressure to 1000 pounds in the presence of a mixture of copper, iron and lead chromates as catalysts, supported on suitable carriers. Aluminum and zinc oxides may function as promoters.

U.S.P. 2,365,895. Treatment of Hydrocarbons. J. M. Mavity to Universal Oil Products Company.

A catalyst comprising a major proportion of titanium dioxide and a minor proportion of molybdenum oxide is employed. The titanium dioxide carrier is impregnated with 2-30 percent by weight of molybdena.

U.S.P. 2,366,531. Dehydrogenation of Hydrocarbons. V. N. Ipatieff and V. Haensel to Universal Oil Products Company.

Hydrocarbons are dehydrogenated in the presence of a catalyst obtained by reducing shaped bodies of zinc oxide, copper oxide and alumina at 450-700° C. with carbon monoxide or a mixture of carbon monoxide and hydrogen. Dehydrogenation is carried out at 400-600° C. and liquid space velocities of 0.5-10.0.

U.S.P. 2,367,479. Dehydrogenation of Aliphatic Hydrocarbons. I. L. Wolk to Phillips Petroleum Company.

A process for the preparation of butadiene from n-butane is described which comprises dehydrogenating n-butane to produce a butene-containing stream, immediately contacting said stream with a relatively cool solvent selective for butene to reduce the temperature of said stream sufficiently to prevent side reactions therein, separating butene from said solvent, dehydrogenating the butene to produce a butadiene-containing stream, immediately contacting the last-named stream with a relatively cool sol-

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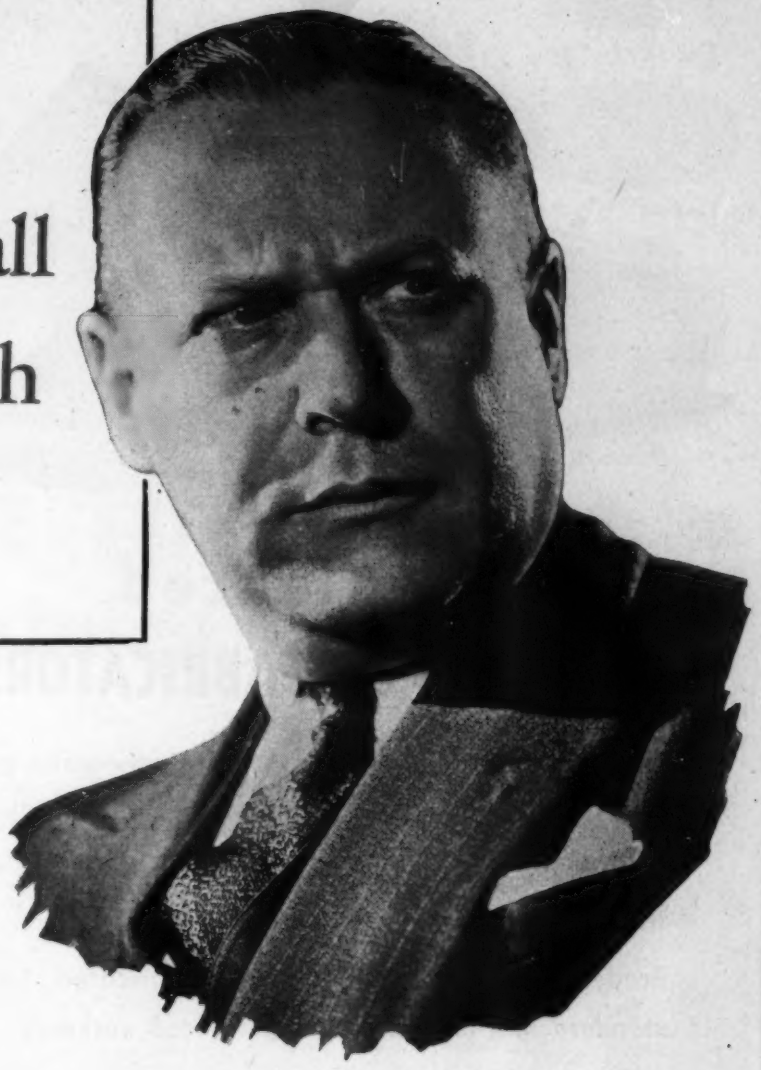

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vent selective for butadiene to reduce the stream temperature sufficiently to prevent side reactions and separating butadiene from the solvent.

U.S.P. 2,367,620, 2,367,621, 2,367,622, 2,367,623. Process for Dehydrogenation of Hydrocarbons. W. A. Schulze, J. C. Hillyer and H. E. Drennan to Phillips Petroleum Company.

Low-boiling aliphatic olefin stocks comprising C_4 or heavier hydrocarbons are diluted with a considerable proportion of diluent comprising in turn considerable quantities of CO_2. The resulting mixture is treated to dehydrogenate the olefins oxidatively, i.e., with formation of diolefins and water with a water-resistant catalyst consisting of bauxite impregnated with a minor portion of barium hydroxide at temperatures of 1100-1300° F. The diolefins produced are separated.

Liquefied Petroleum Gas Group Selects Officers

Ernest Fannin of Fannin's Gas and Equipment Company, Phoenix, Arizona, has been elected president of Liquefied Petroleum Gas Association to succeed Louis Abramson, Jr., Petrolane Gas Corporation, New Orleans. Harry K. Strickler, Protane Corporation, Erie, Pennsylvania, was re-elected first vice president and Charles O. Russell, Thermogas Company, Inc., Des Moines, Iowa, second vice president. Sectional chairmen are: H. Emerson Thomas, Fuelite Natural Gas Company, Lexington, Massachusetts, Eastern; Charles O. Russell, Midwest; Ernest Fanning, Pacific; and Selwyn Turner, National Butane Gas Company, Mobile, Alabama, Southern.

New members named to the board are: Walter F. Verkamp, Cincinnati; B. T. Harris, Little Rock, Arkansas; F. F. Hampson, Yakima, Washington; Lee H. Barker, Wisconsin Rapids, Wisconsin; Thomas, Fannin and Russell.

PAW Envoy Returns From Chinese Mission

Martin J. Gavin, assistant director of the foreign refining division of the Petroleum Administration for War, returned May 10 from two months' investigation of petroleum conditions in the interior of China. His findings were not to be made public because of security regulations.

Gavin left for China February 17 at the request of the National Resources Commission of the Ministry of Economic Affairs of China to advise that country on matters concerning petroleum and synthetic fuels as a part of the war program. He was a guest of Dr. Wong Wen-hao, minister of economic affairs in Chiang Kai-shek's cabinet and chairman of the Chinese war production board.

Analysis of Oklahoma Oils

The United States Bureau of Mines on May 24 released the third of a series of reports on analysis of Oklahoma crude oils, copies of which (Report of Investigations 3802) may be obtained from the Washington office.

The report, prepared in cooperation with the State of Oklahoma and the American Association of Petroleum Geologists, contains Hempel analyses of 248 crude oil samples from 153 fields.

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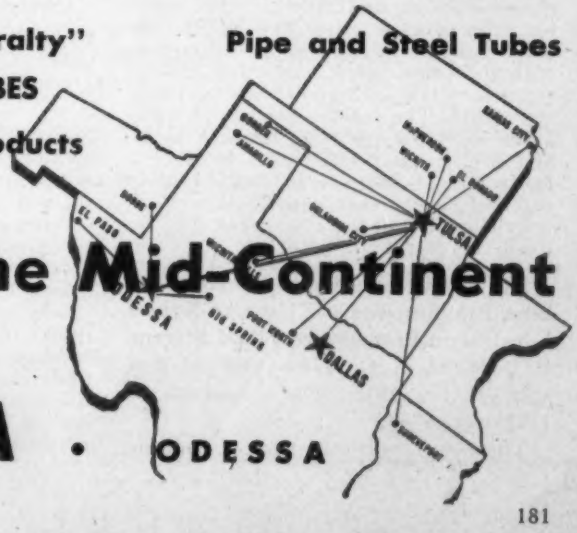

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The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Solubility of Air in Petroleum Oils. W. A. CRAIG, *Petroleum World*, **42**, No. 3 (1945) pp. 43-45.

The Lockheed Aircraft Company has prepared data on the solubility of air in gasoline and derived a formula for determining the amount of air dissolved in liquid gasoline under any given conditions. Using the formula it is possible to calculate the volume of air released and absorbed by gasoline when the conditions are changed. A typical aircraft fuel will dissolve about 22 volumes of air to 100 volumes of gasoline for each atmosphere of air pressure. Approximately 8 volumes of air dissolve in 100 volumes of oil. The foaming of lubricating oils at high altitude is discussed. The data are also useful to the designer of hydraulic systems. The prevention of oil sludging by removal of air through introduction of a reducing gas to combine with the oxygen is considered. The pumping of air-oil mixtures is briefly discussed.

Determination of Equilibrium Constants for Butanes and Pentanes. H. PINES, B. KVETINSKAS, L. S. KASSEL AND V. N. IPATIEFF. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 631-37.

The isomerization of butane and pentane were studied under conditions such as to minimize the secondary reactions. Depending upon the temperature used the experiments were carried out in sealed tubes, a stirring autoclave, or a continuous flow apparatus. These apparatus are described in some detail. The catalysts used were aluminum bromide or aluminum chloride. The results for butane agree with previous equilibrium determinations, and may be represented by $R \ln K^{o}O = (2318/T) - 4.250$. The corresponding heat of reaction disagrees with the calorimetric value, but the entropy is in fair agreement with the third-law value. The results for pentane disagree with the previous measurements, and lead to the equation $R \ln K^{o}O = (1861/T) - 1.299$. The indicated heat of reaction agrees exactly with the calorimetric value, and the agreement with the third-law entropy is good.

Heats of Combustion of Benzene, Toluene, Ethylbenzene, o-Xylene, m-Xylene, p-Xylene, n-Propylbenzene and Styrene. E. J. PROSEN, R. GILMONT AND F. D. ROSSINI. *J. Res. Natl. Bur. Standards* **34** (1945) pp. 64-71.

The heats of combustion of benzene, toluene, ethylbenzene, o-xylene, m-xylene, p-xylene, n-propylbenzene, and styrene were measured with a bomb calorimeter. The heats of combustion at 25° C. and constant pressure, of the liquid hydrocarbon in gaseous oxygen to form gaseous carbon dioxide and liquid water, with all the reactants and products in their thermodynamic standard reference states are, in international kilojoules per mole: benzene, 3267.09 ± 0.43; toluene, 3909.31 ± 0.49; ethylbenzene, 4564.09 ± 0.72; o-xylene, 4552.10 ± 1.02; m-xylene, 4551.10 ± 0.62; p-xylene, 4552.09 ± 0.91; n-propylbenzene, 5217.37 ± 0.68; styrene 4394.14 ± 0.82. With the factor $\frac{1}{4.1833}$, the corresponding values in kilocalories per mole are benzene, 780.98 ± 0.10; toluene, 934.50 ± 0.12; ethylbenzene, 1091.03 ± 0.17; o-xylene, 1088.16 ± 0.24; m-xylene, 1087.92 ± 0.15; p-xylene, 1088.16 ± 0.22; n-propylbenzene, 1247.19 ± 0.16; styrene, 1050.40 ± 0.20. The accuracy of the values of the heats of combustion is discussed.

The Composition of Scottish Shale Oil. Part I. J. W. COOK, N. PERCY, AND J. M. ROBERTSON. *Jour. Soc. Chem. Ind.* **64** (1945) pp. 26-27.

The authors' communication is concerned with a component of the wax from Scottish shale oil. They note that eivdence has been presented that paraffin wax from many sources consisted chiefly of normal paraffins. The crude wax was submitted to a preliminary fractional distillation, and the fraction boiling from 190-230° C. at 0.6 mm. pressure was repeatedly recrystallized from ether, after washing with concentrated sulfuric acid. The purified hydrocarbon had the elementary composition of a higher paraffin and melted at 67.6-68.4° C. Synthetic n-hentriacontane was prepared from palmitone by the method of Kipping and reduced to the hydrocarbon. The hydrocarbon so formed was redistilled and crystallized from alcohol. It formed lustrous white leaflets of melting point 67.3-68.2° C. X-ray examination indicated the identity of the hydrocarbon from shale oil with n-hentriacontane.

Heats of Formation and Combustion of 1,3-Butadiene and Styrene. E. J. PROSEN AND F. D. ROSSINI. *J. Res. Natl. Bur. Standards* **34** (1945) pp. 59-63.

The heats of formation and of combustion of gaseous and liquid 1,3-butadiene and styrene are given as follows:

Compound	State	Heat of Combustion[a] at 25° C. $-\Delta H_c^{\circ}$ 298.16	Heat of Formation[b] at 25° C. ΔH_f° 298.16
		kcal/mole	kcal/mole
1, 3-butadiene	Gas	607.907±0.225	26.748±0.233
1, 3-butadiene	Liquid[c]	602.788±0.226	21.629±0.234
Styrene	Gas	1060.79±0.22	35.106±0.243
Styrene	Liquid	1050.40±0.20	24.716±0.221

$-\Delta H_c^{\circ}$ 298.16 is the heat evolved in the combustion of the hydrocarbon, in the state indicated, in gaseous oxygen to form gaseous carbon dioxide and liquid water, at 25° C. and constant pressure. ΔH_f° 298.16 represents the heat increment in the process of formation of the hydrocarbon, in the state indicated, from its elements, at 25° C.

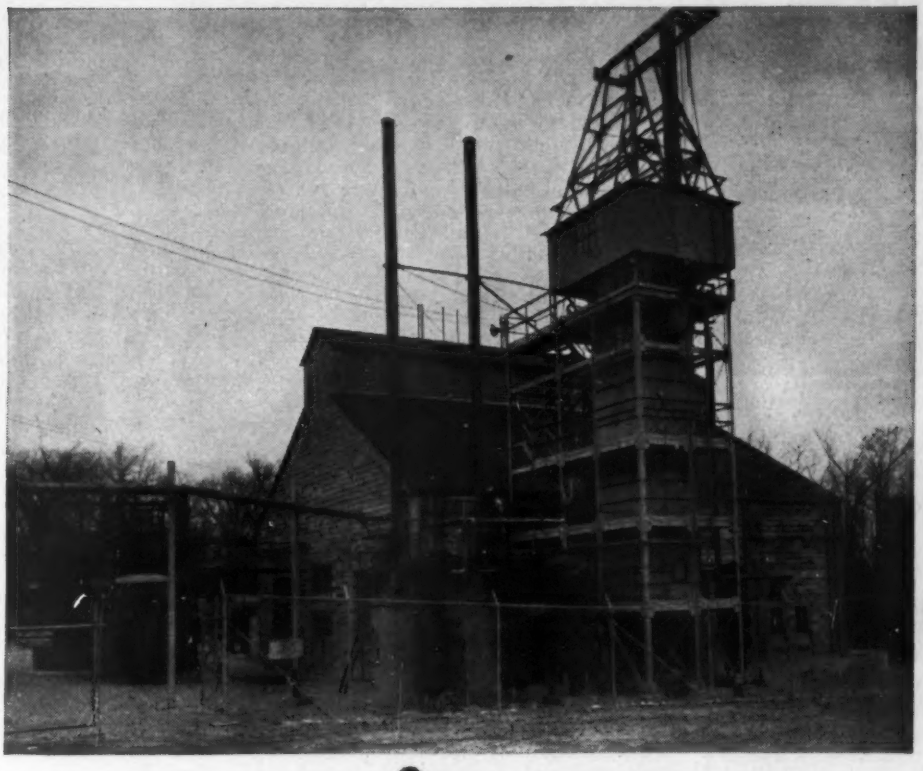
Chemical Compositions and Reactions

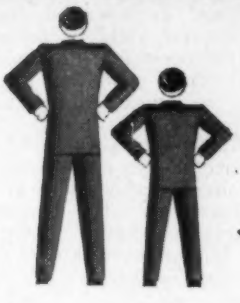
Catalytic Isomerization of 1-Hexene. R. G. HAY, C. W. MONTGOMERY, AND J. COULL. *Ind. & Eng. Chem.* **37** (1945) pp. 335-39.

The normal 1-olefins can be catalytically isomerized to branched-chain olefins that have more desirable properties for use as a motor fuel. The skeletal isomerization of 1-hexene was investigated using several catalysts in the temperature range 285-500° C. and at space velocities of 0.1 to 1.9 reciprocal hours. The products obtained were chiefly methylpentenes with lesser quantities of dimethylbutenes and small amounts of higher- and lower-boiling hydrocarbons. The results indicate that the catalysts must be acidic or have absorbed hydrogen ions that are essential to the reaction. The isomerization appears to be stepwise: 1-hexene → methylpentenes → dimethylbutenes. It was found that reaction rates increased with temperature but the extent of isomerization decreased with increasing temperature. The optimum isomerization temperature at 0.6 reciprocal hours space velocity was found to be about 335° C. The data are presented in one table and six figures.

Heptenes and Heptanes from Propylene and Butylenes. V. N. IPATIEFF AND R. E. SCHAAD. *Ind. & Eng. Chem.* **37** (1945) pp. 362-64.

Polymers formed from approximately equimolecular mixtures of propylene and isobutylene at 135° C. and 38 atmospheres pressure in the presence of solid phosphoric acid catalyst contained 40-





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45% of heptenes, 10-15% of octenes, 25-30% of a mixture of decenes and undecenes, and 10-25% of higher boiling polymers. Hydrogenation of the heptenes yielded a heptane fraction, most of which was 2,3-dimethylpentane, with an octane number of 89 to 90 by the Motor method. Addition of 1 cc. of tetraethyllead increased the octane number to 98.5. Hydrogenated polymers, consisting mainly of decanes and boiling from 155° to 163° C., had an octane number of 89; a higher boiling hydrogenated product boiling from 163° to 175° C. and containing chiefly undecanes and dodecanes had an octane number of 93.6. Propylene and n-butylene mixtures did not polymerize at 135°, but at 191° C. they formed mono-olefinic polymers that on hydrogenation yielded paraffinic mixtures. The 150° C. end-point fraction had an octane number of 56 to 62. Data are presented in detail in tabular and graphical form, and a bibliography of 9 references is included.

Naphthene Pyrolysis for Butadiene. L. Berg, G. L. Sumner, Jr., and C. W. Montgomery. *Ind. & Eng. Chem.* **37** (1945) pp. 352-55.

Under suitable conditions of temperature and contact time, usually above 1300° F. and below 1 second, all normally liquid hydrocarbons yield some butadiene upon thermal decomposition. The nature of the hydrocarbon decomposed has a marked effect upon the yield of butadiene. Other conditions being equal, the yield of butadiene increases for different charge stocks in the order: aromatics, paraffins, olefins, naphthenes, unsaturated naphthenes. Considering the decomposition of normally liquid pure hydrocarbons, cyclohexene appears to give the highest yield of butadiene on thermal decomposition. Following in decreasing order of yield, are: 3-methylcyclohexane, cyclohexane, ethylcyclohexane, methylcyclohexane, 1,4-, 1,2- and 1,3-dimethylcyclohexanes, and decalin. Of the hydrocarbons commercially available, cyclohexane appears to be the best of the normally liquid hydrocarbons for the production of butadiene by thermal cracking. Maximum yields of butadiene from cyclohexane were obtained when temperature and contact time were regulated to give 35 pounds of 3-carbon and lighter compounds per 100 pounds of cyclohexane charged. The results indicate that shorter contact times favor a higher percentage of butadiene in the C_4 fraction. They also show that, at constant contact time in the temperature range 1400-1600° F., lower temepratures yield higher percentages of butadiene. The data secured in the work are presented graphically in five figures.

Carbon Formation in Catalytic Cracking. A. Voorhies, Jr. *Ind. & Eng. Chem.* **37** (1945) pp. 318-22.

When petroleum hydrocarbons undergo extensive reactions in the presence of solid catalysts, carbon-containing deposits usually accumulate on the catalyst and decrease its activity, so that periodic regeneration is necessary. A conspicuous exception to this is high-pressure catalytic hydrogenation in which the catalyst may retain its activity for a year or longer. Carbonaceous deposits, or coke, formed in catalytic cracking, is apparently a hydrocarbon of low hydrogen content, the nature of which may vary with the feed stock or operating conditions. The material also contains sulfur derived from the feed stock. Although the extent of carbon formation in catalytic cracking depends on the type of catalyst, the feed stock, and the operating conditions, it has been found that there is an intrinsic uniformity in the way the carbon deposit on the catalyst increases with time. Correlations of striking simplicity and of considerable utility have resulted from a study of such data. The usefulness of the relations developed extends beyond the field of carbon yields to include an equation defining the interdependence among feed stock conversion, feed rate, and length of period between catalyst regenerations. These relationships apply equally to fluid and fixed-bed cracking. The results recorded by the author were obtained both in pilot plant and semi-plant scale systems. The correlations derived have been applied in practice to commercial-scale units.

Manufacture: Processes and Plant

Surface Area of Catalysts. H. E. Ries, Jr., R. A. Van Nordstrand, and J. W. Teter. *Ind. & Eng. Chem.* **37** (1945) pp. 310-17.

Surface areas of catalysts are important because change in catalytic activity may be caused by change in surface area. Area determinations provide a method for following changes in catalyst structure that occur at elevated temperatures. The measurement of area provides a means for determining whether promoters and supports improve catalysts by increasing or maintaining area or by qualitative changes that increase catalyst activity per unit of surface area. The measurement may give valuable information concerning the structure and function of catalyst supports. The paper deals principally with adsorption isotherm area measurements of a supported catalyst and its components. Nitrogen adsorption isotherms were used to follow area changes of a supported catalyst after heating for various periods at 340°, 400°, 500°, 600°, and 650°C. Area values were obtained for the diatomaceous earth support after 340° and 650° C. heat treatments and for the unsupported catalyst after a 340° treatment. Calculated areas show that the supported catalyst has a greater area than either the unsupported material or the support. The supported catalyst loses 5 percent of its area at 500° C., 26 percent at 600°, and 75 percent at 650°. The support suffers a loss of 39 percent at 650° C. Fair agreement was found between the measured area of the support and the area of a model based on electron microscope pictures. An adsorption-desorption isotherm determination on the supported catalyst demonstrates a pronounced hysteresis effect that is discussed in relation to pore structure. Consideration is also given to Va/Vm isotherms as a means for studying

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Fluid Fixed Bed. C. L. THOMAS AND J. HOEKSTRA. *Ind. & Eng. Chem.* **37** (1945) pp. 332-34.

The passage of gases or vapors upward (counter to gravity) through a mass of powdered solid produces the "fluidized fixed bed". The passage of the gas or vapor causes the powdered solid to become mobile so that it moves about resembling an agitated liquid. The particle size of the powder is regulated so that little of it is carried out of the reaction zone with the gas or vapor. The fluidized fixed bed is particularly adapted to catalytic reactions in which a reaction occurs that is accompanied by a large heat of reaction. The movement of the powdered solid tends to prevent the formation of localized high-temperature zones or "hot spots". Several factors determine the useful range of flow rates: (1) The diameter of the tube should be 2 inches or greater to avoid wall effects; (2) the density of the powder is related to the air rate necessary to fluidize it in the sense that the greater the density the greater the air rate needed. Most powders fall within the bulk density range of 0.4 to 1.0 gram per cc.; (3) the air rate required to fluidize the powder increases with particle size. Particles are commonly in the range 40 to 100 mesh. With these densities and sizes, the air rate ranges from 0.5 to 1.5 feet per second linear velocity as calculated for the empty tube. When regeneration is effected with air in the fluidized fixed bed, there is a fairly uniform temperature rise throughout the catalyst zone. Burning occurs throughout the catalyst, and the motion of the catalyst appears to prevent the formation of hot spots. This is in contrast to regenerations of true fixed bed catalysts. The results of two cracking runs are given, one at 850° and the other at 950° F. Also data are given for a hydrogen transfer run on a gasoline obtained by catalytic cracking.

Silica-Alumina Gels. P. B. ELKIN, C. G. SHULL, AND L. C. ROESS. *Ind. & Eng. Chem.* **37** (1945) pp. 327-31.

The investigation was planned to study the effect of the method of preparing silica-alumina gels on the physical structure of the gels. Three series of gels of various concentrations, made by (a) precipitation in sequence, (b) mixing wet gels, and (c) impregnation of partially dried silica gel, were examined by nitrogen adsorption, small angle X-ray scattering, and X-ray diffraction. Specific surfaces were smaller for (a) and larger for (b) than those expected for mixtures of the dried silica and alumina gels. Maxima in curves for specific surface vs. alumina content for B and C at about 5 percent by weight correlated with minima in average particle size. No alumina was detected by X-ray diffraction for gels containing as much as 26 percent by weight of alumina. Particle size distributions for the gels were determined by small-angle X-ray scattering technique. These showed maxima in particle size at from 30 to 65 Å. The results indicate that silica-alumina catalysts prepared by the three methods are not simple mixtures of silica particles and alumina particles such as would be expected from mixing fine powders of the two materials. There is no diffraction evidence of chemical compound formation, so it seems reasonable to assume

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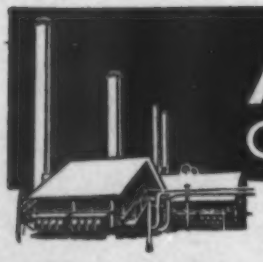

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that the observed phenomena are caused by physical effects. The data are presented in two tables and eight figures.

Promoted Chromia-Alumina Catalyst for Converting n-Heptane to Toluene. R. C. ARCHIBALD AND B. S. GREENSFELDER. *Ind. & Eng. Chem.* **37** (1945) pp. 356-61.

The development of a promoted chromium oxide-alumina catalyst that is particularly active for the cyclization of normal paraffins to aromatics is described. The activity of this catalyst depends in part on the choice of the proper form of alumina as the support and in part on the addition of two elements that are effective promoters for the dehydrogenation and the cyclization reactions. At high efficiencies of conversion of pure n-heptane, maximum concentrations of toluene in the liquid product exceeding 80 percent can be attained with the catalyst. The average is about 75 percent over a period of 10 hours. Poisoning of the reaction by hydrocarbons that cannot be converted directly to aromatics was studied, including such hydrocarbons as n-pentane, isopentane, 2-pentene, cyclopentane, cyclopentene, and methylcyclopentane. These had a comparatively small effect on the conversion for the first few hours, but the poisoning increased considerably as the runs progressed beyond the point of maximum conversion, so that after 25 hours the average conversion of n-heptane containing 10 percent of any one of these compounds tested only half as great as for pure n-heptane. Aromatics in the feed were found to act simply as inert diluents.

Production of Isoparaffins. V. I. KOMAREWSKY AND L. WARSON. *Ind. & Eng. Chem.* **37** (1945) pp. 323-26.

Any hydrocarbon decomposing under the action of aluminum chloride and forming unsaturated fragments will form a saturated product by the processes of alkylation, intermolecular dehydrogenation-hydrogenation, and conjunct polymerization. The course of the reaction in the case of paraffins, cycloparaffins, and aromatics, is briefly traced. The products obtained in aluminum chloride cracking should contain a large percentage of low molecular weight isoparaffins, and as a consequence should possess a high antiknock value and good tetraethyllead susceptibility. In general, the gasoline obtained from the cracking of straight-run distillate has an 80 octane rating and shows good lead susceptibility. It was found that the cracking reaction can be directed so that the product with any desired end point will result. The charging stocks used in the work were Pennsylvania, California, and Trinidad gas oils, and Trinidad and Michigan naphthas. Complete specifications of these materials are given. The apparatus used in the work is described. The cracking of straight-run gas oils and naphthas in the presence of aluminum chloride results in the production of gaseous and liquid hydrocarbons completely free from olefins. This fact distinguishes these products from those obtained in thermal or catalytic cracking. The gaseous products contain large amounts of isobutane (30 percent by volume of the charge). The liquid product boils entirely in the aviation gasoline range, having an end point of 150° C. and is composed mainly of paraffin hy-

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drocarbons (83-95 percent). The data secured in the work are presented in some detail in six tables.

Catalysis in Synthetic Liquid-Fuel Processes. H. H. STORCH. *Ind. & Eng. Chem.* **37** (1945) pp. 340-51.

The catalytic phenomena of three synthetic liquid fuel processes are discussed. These are the synthesis of liquid hydrocarbons from a mixture of hydrogen and carbon monoxide, commonly called the Fischer-Tropsch process, the hydrogenolysis of carbonaceous materials such as coal and coal tar, usually termed the Bergius-I. G. process, and the catalytic cracking or re-forming of fractions from petroleum or from middle oils obtained by way of the hydrogenation of coal and coal tar. The catalytic reactions of the last two processes involve rupture of carbon from carbon, carbon from oxygen, carbon from nitrogen and carbon from sulfur. The data secured in the work are presented in considerable detail in six tables and fifteen figures. A bibliography of 52 references is included.

Products: Properties and Utilization

The Extreme Pressure Lubricating Properties of Some Chlorinated Compounds as Assessed by the Four-Ball Machine. W. DAVEY. *Jour. Inst. Petr.* **31** (1945) pp. 73-88.

A study of the extreme pressure lubricant properties of some chlorinated compounds was made, using the Four-Ball machine. Certain chlorinated compounds were tested as neat compounds and blended in genuine Pennsylvania 150 Neutral Oil. Anglamol 40, a proprietary chlorinated compound, was used as the standard reference material. The other materials were rated on their performance relative to this standard. On this rating, benzo-trichloride, benzyl chloride, hexachlorethane, and carbon tetrachloride are superior to Anglamol 40, whereas tetrachlorethane, chloroform, p-chloronitrobenzene, ethylene dichloride, trichlorethylene, and p-dichlorbenzene were inferior in E. P. properties. The mechanism of the development of E. P. properties by chlorinated compounds is discussed. The results enable the E. P. properties of a chlorinated compound to be predicted from its formula. The apparatus and methods of test are described in some detail and the results are presented in detail in tabular and graphical form. It was concluded that the E. P. properties of chlorinated compounds are caused by the liberation of atomic chlorine under extreme conditions. The liberated atomic chlorine forms an additive product with the metal surfaces yielding low wear; the formation of ionic chlorine, e.g. from hydrogen chloride, gives corrosion and high wear. A chlorinated compound will possess good E. P. properties if its molecule (a) contains chlorine atoms that are labile under the conditions of usage, and (b) if it is completely saturated with chlorine, i.e. there being no hydrogen atoms in the aliphatic chain which can combine with chlorine to give hydrogen chloride. A compound having chlorine attached to an aromatic nucleus will exhibit only slight E. P. properties.

Improvements in Lubricating Greases. M. W. WEBBER. *Jour. Inst. Petr.* **31** (1945) pp. 89-102.

The manufacture of soap-thickened lubricating greases started about 1860, and for perhaps sixty years developments were slow and highly empirical. During the last fifteen years development has been more rapid and the industry is now producing lubricants of uniform consistency, greater purity, wider temperature range and greater load carrying capacity. Subjects of consistency, purity, stability, syneresis, stability to pressure, resistance to oxidation, stability to heat, temperature range, extreme pressure applications, additives, ball and bearing greases are discussed. In conclusion the author considers development problems of the future. Improvements in methods of testing are briefly considered and suggestions offered as to new analytical procedures.

Analysis of the Light Constituents in Crude Petroleum by Low-Temperature Fractional Distillation. R. J. ASKEVOLD AND M. S. AGRUSS. *Ind. & Eng. Chem., Anal. Ed.* **17** (1945) p. 241.

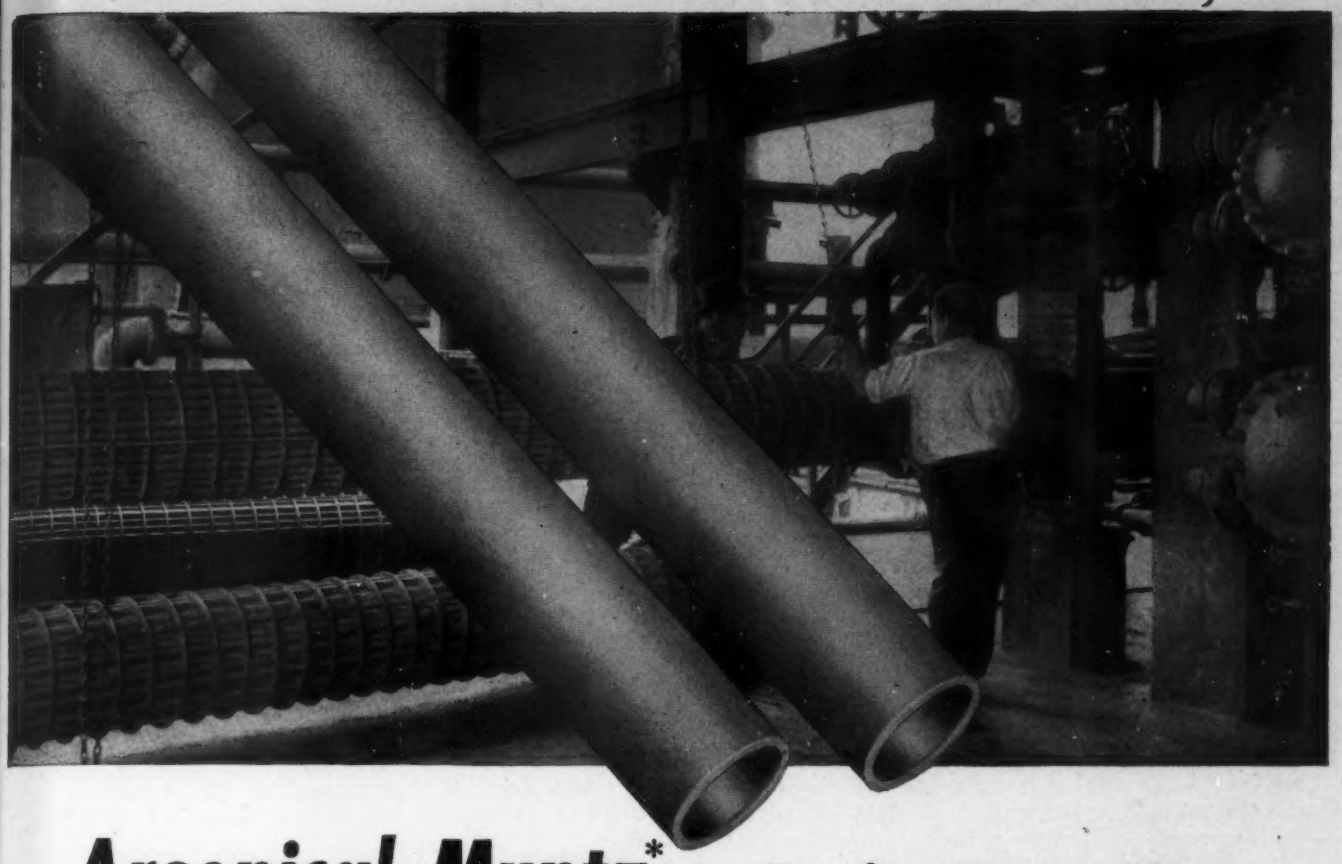
It is frequently desirable to know the composition of the light gases occurring in the original crude oil charge to distillation or cracking units. The usual low-temperature fractional distillation columns are not entirely suitable because the light components in crude oil are present in small quantities, and difficulty is also had with water. A still is described in which a fairly large sample is distilled through a small packed column, the packing of which is sodium hydroxide pellets. The overhead from this column passes through the conventional low-temperature fractionating column. Typical analyses are given for Michigan, Van Zandt, Cabin Creek, Eureka, Corning, Mid-Continent, Creole and Cumberland crudes. Some of these showed traces of methane, and all showed appreciable quantities of ethane.

The Use of Petrol and Paraffin Oil as Solvents in the Analysis of Bituminous Surfacing Materials for Roads and Aerodromes. C. M. GOUGH AND E. H. GREEN. *Jour. Soc. Chem. Ind.* **64** (1945) pp. 11-13.

A study was made of the possibility of using gasoline or kerosene as alternate solvents in the analysis of bituminous road materials under emergency conditions when the normal solvents were not obtainable, as in field laboratories. It was found that both gasoline and kerosene can be used with reasonably good results but neither is as reliable as toluene or xylene. The results tend to be slightly on the low side. Gasoline is preferred to kerosene as it gives more accurate results and the method is quicker. Gasoline is not a satisfactory solvent for the analysis of materials containing tar binder, but reasonably good results can be obtained with kerosene, although the method is not suitable for weathered wet sand-tar mixes.

Use of Infrared Heat in Determining Aniline Points. H. T. HOPKINS. *Ind. & Eng. Chem., Anal. Ed.* **17** (1945) p. 269.

Heating by infrared radiation is particularly advantageous in the widely used aniline point test. Heat is ordinarily supplied by the use of a liquid bath or a flame. The substitution of an infrared



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Closed Absorption Tube for Microdetermination of Carbon and Hydrogen. A. LANGER. *Ind. & Eng. Chem., Anal. Ed.* 17 (1945) p. 266.

The use of closed absorption tubes for the microdetermination of carbon and hydrogen has many advantages. The principal advantage is that the closed tubes are less affected by atmospheric conditions. The author describes the development of the original closed tube by Blumer and describes his own modifications, which eliminate the air jacket and the cap and sleeve of the previous modification. Typical carbon and hydrogen analyses are given that indicate that the proposed absorption tube is capable of giving good results.

Combined Manometer-Barometer for Distillation. G. Ross Robertson. Ind. & Eng. Chem., Anal. Ed. 17 (1945) pp. 238-9.

The standard U-shaped manometer suffers from a serious disadvantage in that contaminating vapors readily reach the space that should be a Torricellian vacuum in the closed arm. A manometer described by the author which is the mechanical equivalent of the short U-

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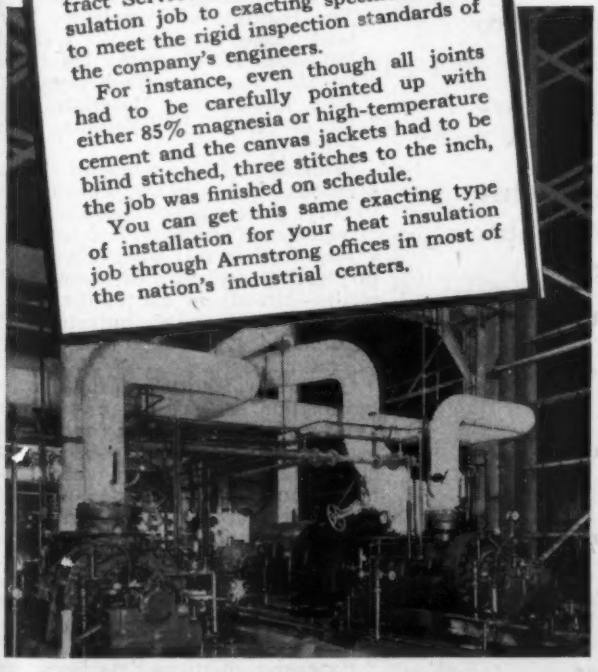

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gage, largely escapes contamination through the interposition of an open mercury well. This modification has given satisfaction for several years in the author's laboratory in the hands of both skilled and unskilled workers. The device also serves as a useful mercurial barometer when the mercury is not standing above zero level in the manometer. The device is described in some detail and is clearly shown in a diagram.

Determination of Water in Hydrocarbon Gases. H. LEVIN, K. UHRIG, AND F. M. ROBERTS. *Ind. & Eng. Chem., Anal. Ed.* **17** (1945) pp. 212-15.

The authors describe a method for determining water in normally gaseous hydrocarbons. It is based on the observation that when a gas containing moisture is contacted with cold dehydrated acetone, the water is retained by the acetone, in which it can be determined by reaction with acetyl chloride, titrating the liberated acid. Olefins and diolefins do not interfere and provision is made for correcting for the effect of acidic or basic constituents of the sample. The apparatus used is described in detail, as well as the manipulative procedure. Typical determinations of water in butane, propane, butadiene, and typical plant gases indicate excellent agreement between water known to be present and found by the method. A bibliography of 14 references is included.

Book Reviews

Standard Methods for Testing Petroleum and Its Products

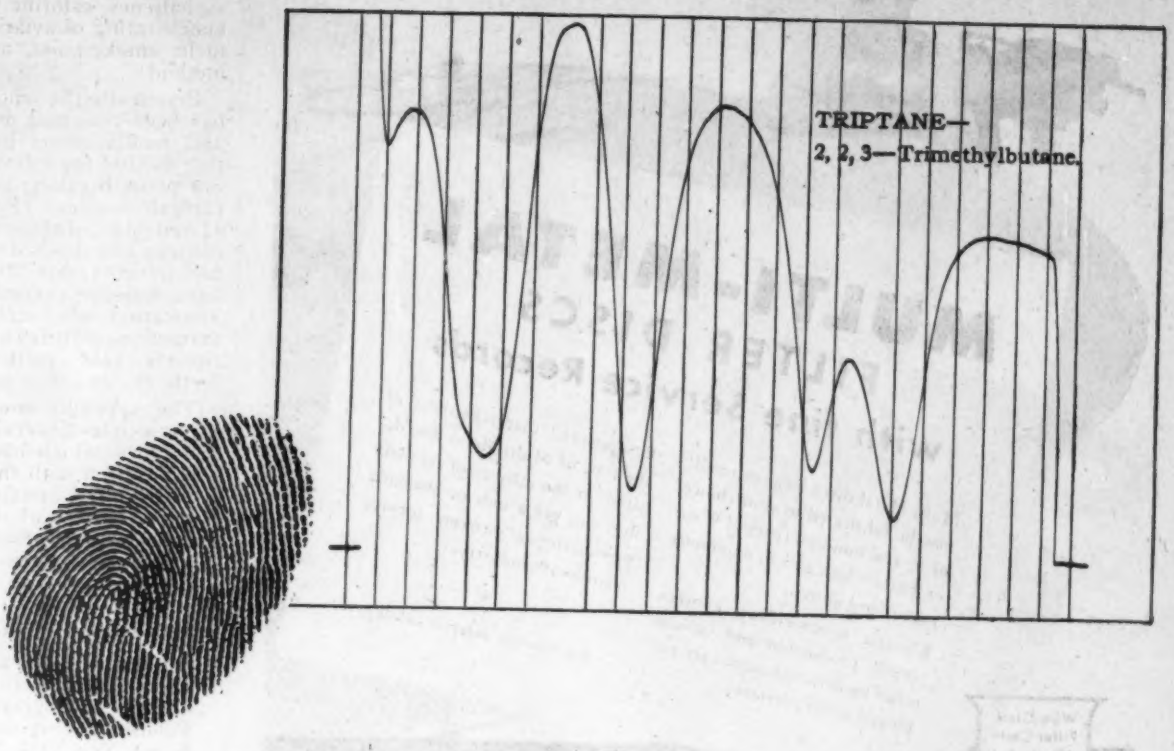
(Sixth Edition, 1945). Published by The Institute of Petroleum, 26 Portland Place, London, W. 1, England. 539 pages, 155 diagrams. 15s. Od. (Obtainable also from The American Society for Testing Materials, 260, So. Broad Street, Philadelphia, Pennsylvania, at $3.50.)

Widening of the scope of "Standard Methods," begun in the previous edition, to cover materials not consisting entirely of petroleum products, has been carried a step further this year. Five methods for testing asphaltic bitumens and asphalts—already in use in the road material and electrical industries—have been included, and others are under consideration.

Other new methods deal with the determination of hydrogen sulphide in gases and distillates, mercaptan sulphur in light distillates, and total sulphur in gaseous and distillate products. This latter method is an improved lamp method, and three procedures for working up the absorber solution—volumetric, gravimetric and turbimetric—are described. By means of the latter procedure, a determination of a sulphur content as low as 0.0001 percent by weight may be completed within six hours.

Extensive additions have been made to the method for determining the soluble bitumen content of asphaltic bitumen and asphalts, separate procedures being described for bitumen contents of 95-100 percent, 50-95 percent and below 50 percent respectively. Additions have also been made to the specific-gravity methods, which now embrace gases, and the range of I.P. hydrometers has been extended to 0.600-0.650. A mercury manometer may now be used in place of a Bourdon-type gauge in the vapor-pressure determination.

The procedures of the following meth-



FINGER PRINT OF A HYDROCARBON

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The UOP infra-red spectrometer "finger prints" hydrocarbons—a valuable aid to our technologists in analyzing hydrocarbon mixtures.

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Safety Valves • Relief Valves
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SINCE 1872 — *Makers of Pressure-Safety Appliances for the Power, Mechanical, and Process Industries*

ods have been modified: Aniline point, asphaltenes, calorific value, iodine value, knock-rating of aviation fuels and motor fuels, smoke-point, and sulphur (bomb method).

Practically the whole of the apparatus has been reviewed during the past year and modifications have been made to that used in the following methods: Aniline point, breaking point, calorific value, carbon residue (Ramsbottom), color (Lovibond), dielectric strength, diluent content (for both diesel fuel and motor fuel diluent), distillation of crude petroleum, halogen content, oxidation test for lubricating oils, sampling, sediment by extraction, sludging value, sulphur (quartz tube method), T.E.L. (HCl method), and viscosity (absolute).

The Appendix now contains a note on the principles governing oil measurement procedure, which has been drawn up in collaboration with the American Society for Testing Materials to establish a code acceptable in both the British Empire and the United States. Tables for the conversion of metric weights to long and short tons are also included.

The Chemistry of Acetylene

By Julius A. Nieuwland, C. S. C., and Richard R. Vogt (American Chemical Society Monograph Series). Reinhold Publishing Corporation, 330 West 42nd Street, New York. 220 pages. Price $4.00.

This work presents a brief but fairly complete account of the preparation, properties and reactions of acetylene along with an extensive classified bibliography. Arrangement is based on a classification of the methods of preparation and type reactions of acetylene rather than on considerations of historical or industrial status. A section points out the principal stepwise syntheses from acetylene through substituted acetylenes. Numerous reactions of other acetylenic compounds are cited.

Atlantic Recognizes Safety Record at Philadelphia

The mechanical department at the Philadelphia refinery of The Atlantic Refining Company has established a new safety record for that plant by working a total of 1,877,724 man hours without a lost-time accident.

This achievement represents the work of 1276 men over a period of 8½ months. A plaque emblematic of the safety championship was presented the department, and each workman will receive a pin signifying his individual share in helping win the title.

The inspection department was awarded the championship last year with a total of 1,441,916 man hours worked without a lost-time accident, but though its record is still unmarred its man hours were exceeded by the larger mechanical group.

A 60 percent reduction in lost-time accidents during 1945 has been set as the goal for the refinery.

Buys West Texas Plant

Lynn Oil Company, New Orleans, has purchased Gar-Tex Refinery, Inc.'s 100-barrel skimming plant at Post, Texas. The new owner proposes to enlarge the plant, as its property is isolated from pipe lines.

Bethlehem treated and oil-quenched nuts in valve installations.

For high temperatures

. . . OIL-QUENCHED NUTS

There's no need to worry about nut failure when you use Bethlehem oil-quenched nuts on your studs and bolts. For thousands of installations in oil-refinery, power, chemical and industrial-plant equipment prove these medium-carbon-steel nuts satisfactory for high-temperature, high-pressure applications.

Here's why: Bethlehem oil-quenched nuts are hot-forged—that is, the hole is formed at forging temperature by working the hot steel away from the center toward the walls of the die. This produces a more sinewy, fibrous grain structure. Threads are full-size, well-compacted, free from cracks and strains. Corners are sharp, easy for the wrench to grip. Oxidized sides improve corrosion resistance. Bethlehem oil-quenched nuts are made in bolt sizes from ⅜ in. to 3½ in., and meet ASTM specifications for a Class 2H nut.

Our fastenings plant at Lebanon, Pa., also makes the famous Bethlehem treated nut (Class 2); as well as heat-treated alloy studs and bolts for use under high-temperatures and other difficult bolting conditions; plus hundreds of types of standard fastenings. Tell us about your fastening needs. Send your inquiry today to Bethlehem Steel Company, Bethlehem, Pa.

Bethlehem makes every type of Fastening ★ ★ BETHLEHEM STEEL ★ ★

How to Clean Your Gas Coolers!

REGULAR cleaning of gas coolers is a maintenance measure that merits your careful consideration. If neglected, lime-scale and silt build up quickly . . . water capacity is soon reduced.

OAKITE COMPOUND No. 32

is a specially-designed inhibited acidic type material that successfully restores full operating efficiency to gas coolers.

For example, at one fuel oil plant a recommended solution of Oakite Compound No. 32 was introduced into the water side of a cooler. The solution was allowed to "soak" overnight; it was then drained and equipment thoroughly rinsed. The result? An increase of approximately 36% over the capacity before removing lime-scale and silt!

Your nearest Oakite Technical Service Representative can give you complete details concerning this important cleaning job. Or write us direct for full information.

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508 Thames Street, New York 6, N.Y.
Technical Service Representatives Located in All Principal Cities of the United States and Canada

About EQUIPMENT—SERVICE Suppliers

Timken Elects Bergstrom Engineering Vice President

The Timken Roller Bearing Company, Canton, Ohio, has elected Albert E. Bergstrom vice president in charge of all engineering activities of the company. Bergstrom, born in Sweden, graduated from Royal Technical Institute, Stockholm, in mechanical engineering. He came to this country in 1924 as designing engineer for Stearns Conveyor Company, Cleveland. He joined Timken in 1929 as development engineer, was given various engineering and development assignments, later became chief works engineer, and, in 1938, executive engineer.

Harry D. Wagner Added to Foxboro's Cleveland Staff

The Foxboro Company has announced addition of Harry D. Wagner to its staff of engineers serving the Cleveland area, with headquarters at the company's district offices at 1501 Euclid Avenue.

Wagner is well acquainted in the district, having spent much of his business career there. He has had extensive practical training in industrial instrumentation, having supervised installation and operation of instruments in numerous plants, especially in the glass and rubber industries. His experience also has included development of instrument departments and training of personnel in instrument use and maintenance.

Vincent and Gage Given New Duties With Mathieson

G. P. Vincent, manager of the sales development and technical service department of The Mathieson Alkali Works, has been appointed to the newly created position of technical director. In addition to his former duties, he will direct research and technical development and advise on technical matters concerning plant operation. In these latter capacities, he succeeds R. E. Gage, who was director of research and development for 14 years and has now been appointed technical advisor of the company.

Among the developments for which Dr. Vincent is known are his invention of the commercial process of manufacturing sodium chlorite and his contributions to the development of means for the safe production and control of chlorine dioxide. He is also responsible for many of the practical applications of these and other company products in the textile, pulp and paper, food, water supply, and other fields.

G. P. Vincent

R. E. Gage

Dr. Vincent graduated from Hiram College and Cornell University, where he majored in physical chemistry, inorganic chemistry and industrial engineering, and received his degrees of M.S. and Ph.D. He began his business career in 1927, when he entered the research laboratory of Eastman Kodak Company. In 1930 he became research chemist for The Mathieson Alkali Works, and later held successive posts as manager of the research laboratory, assistant to the research director, and manager of the sales development department.

Dr. Vincent is a member of the American Chemical Society, Technical Association of the Pulp and Paper Industry, American Ceramic Society, Cornell Society of Engineers, Chemists' Club, and other organizations.

Gage, as technical advisor, will cooperate with the technical director in various lines of research and development. He is a graduate of Massachusetts Institute of Technology, where he majored in chemistry and chemical engineering. He joined the Mathieson organization as chief chemist, in 1916, and later became chief chemical engineer and, in 1931, director of research and development. During this period he was directly concerned with the development of processes for the manufacture of synthetic ammonia, high-test hypochlorites, sodium chlorite, synthetic rubber, resins, sodium methylate and other products.

Gage is a member of numerous chemical organizations, including the Chemists' Club, the American Chemical Society, the American Institute of Chemical Engineers, and the Society of Chemical Industry.

General Detroit Again Making Prewar Extinguisher

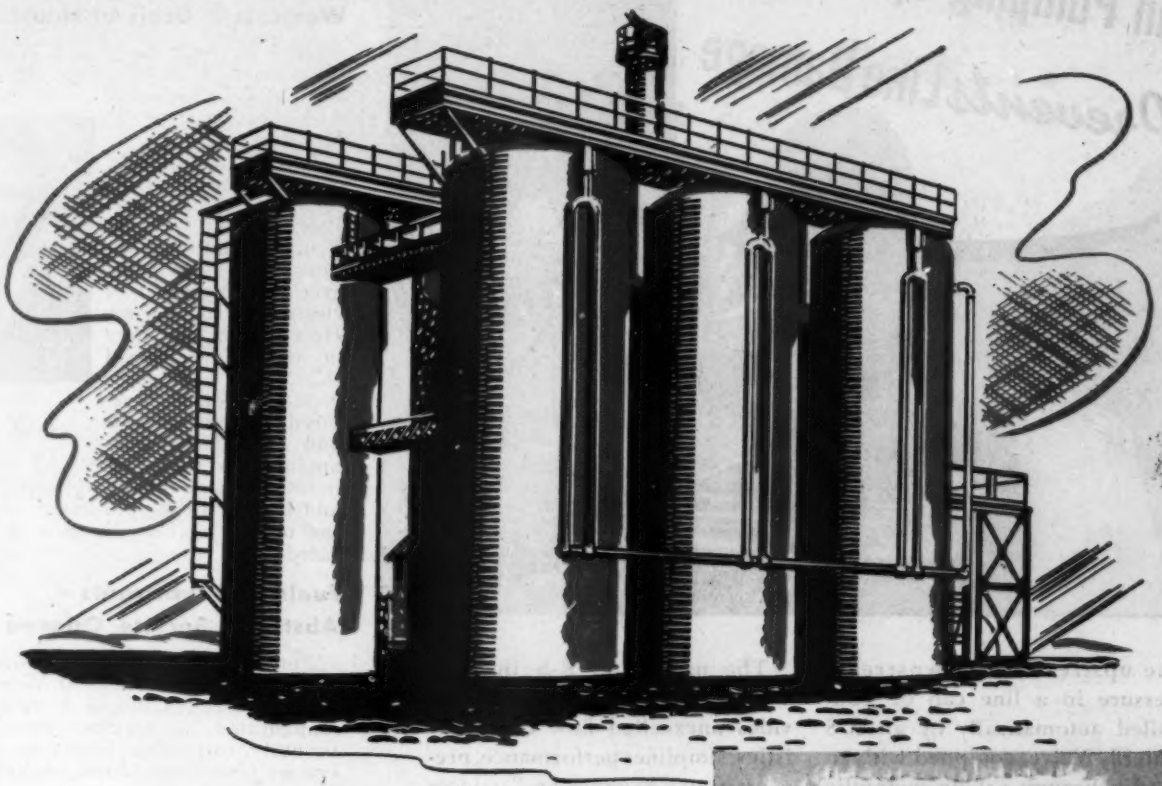
General Detroit Corporation has announced resumption of production of its prewar copper-finish soda-acid and foam-type extinguishers, production of which were suspended early in the war because of material shortages. The items will be available early in July.

Asbestos Manufacturers Form Textile Institute

Asbestos Textile Institute has been organized with offices at 12 South 12th Street, Philadelphia 7, and with the following companies as charter members: Asbestos Textile Company, J. Franklin Burke & Company, Carolina Asbestos Company, Garlock Packing Company, Johns-Manville Corporation, Keasbey & Mattison Company, Philadelphia Asbestos Company, Raybestos-Manhattan, Inc., Southern Asbestos Company, and Union Asbestos & Rubber Company. Purpose of the organization is to estab-

REDUCES

expansion... cuts evaporation losses



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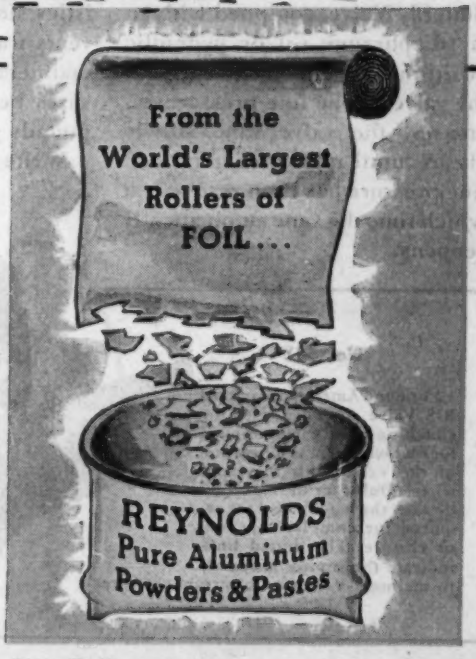
It's LIQUID ALUMINUM!

TWO BIG REASONS dictate the use of aluminum coatings on outdoor tanks. As a liquid, they go on easily . . . form a tough, lasting coat of metallic aluminum which reflects heat and solar waves so destructive to ordinary paint.

In addition, this exterior coating keeps down interior tank temperatures, thus decreasing expansion and evaporation losses. Another big saving!

For long-term satisfaction, insist on aluminum coatings made with Reynolds Powders and Pastes. Only purest Reynolds Aluminum foil stock is used . . . rolled . . . flaked . . . polished for maximum brilliance and reflectivity. Complete *quality control* . . . backed by a quarter-century's experience.

Write for information. Reynolds technical service men will gladly work with you. Reynolds Metals Company, Aluminum Powder and Paste Div., 19 E. 47th St., New York 17, N. Y.



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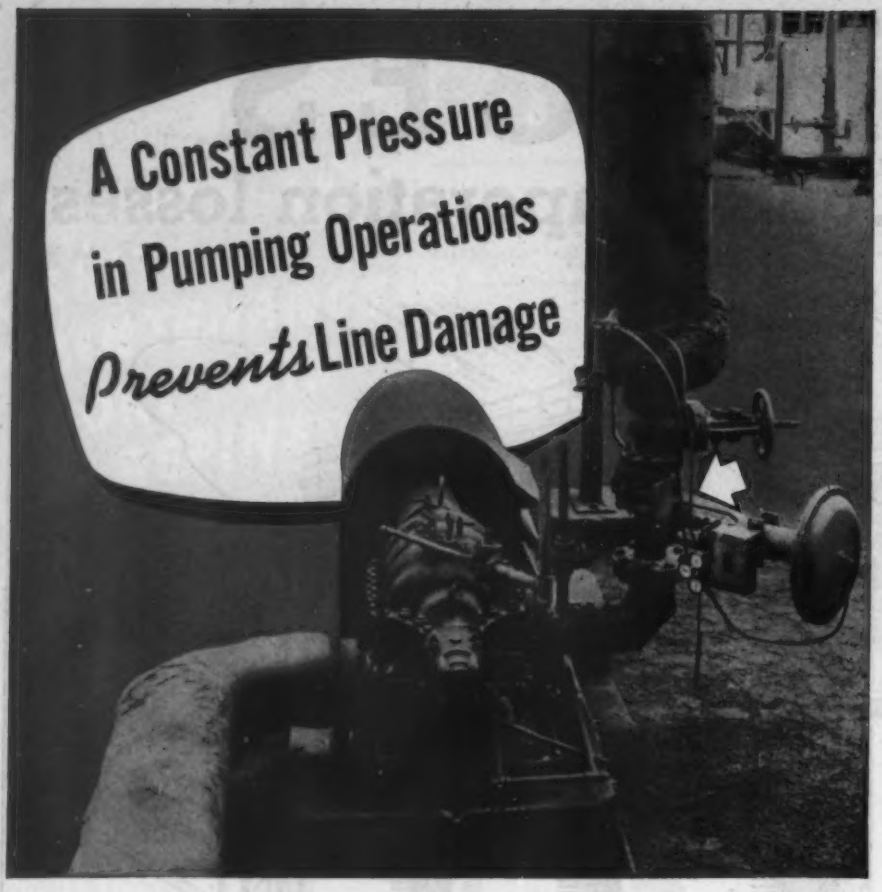

The upstream or downstream pressure in a line can be controlled automatically by an R-S Butterfly Valve, equipped with an air diaphragm, oil or hydraulic positioner cylinder attached to the valve. If the line pressure decreases, the valve vane slowly closes until the predetermined line pressure has been reached, at which time the vane automatically reopens.

The use of an R-S Butterfly Valve as a main control valve provides unexcelled flow characteristics, simplifies performance, prevents water hammer and reduces maintenance. Operates for pressures between absolute and 900 pounds gauge.

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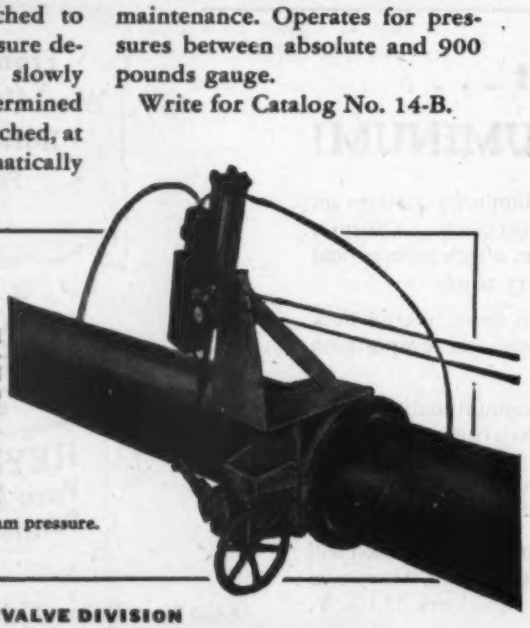

No. 501

125-pound American Standard R-S Valve equipped with declutching unit (patent applied for) which permits operation of the valve with the hand wheel. Only four to six revolutions of the hand wheel are required for complete opening or closure. The dotted lines indicate the piping necessary to maintain a constant upstream pressure.

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R-S Streamlined BUTTERFLY VALVES

lish standards of quality, research, and distribution of technical information.

Officers elected to head the new institute include C. H. Carlough, Carolina Asbestos Company, president; George Marshall, Jr., Raybestos-Manhattan, Inc., vice president; William C. Scott, Keasbey & Mattison Company, treasurer, and Harris D. McKinney, secretary and manager.

Dean D. Ault Representing Westcott & Greis at Houston

Dean D. Ault has joined Westcott & Greis division of American Meter Company as field engineer, with headquarters at Houston.

D. D. Ault

Ault is a graduate of the University of Arkansas, class of 1924, and of Chicago Central Station Institute, holding the degree of bachelor of electrical engineering. He served in the Navy in the First World War. His experience includes work on recording instruments and automatic-control applications in the gas and petroleum industries, and remote automatic control and loading of natural-gas regulators, in the territory where he now will be located.

Fuels and Lubricants Abstracts Service Offered

Petroleum Research Abstracts on Fuels and Lubricants, 30 West Washington Street, Chicago 2, recently has inaugurated a service, issued semimonthly, to provide abstracts of the literature pertaining to fuels, oils and greases.

New Mushroom Technique for Enlarging Storage Tanks

A new method by which storage tanks may be enlarged to as much as twice initial size without dismantling the original structure has been developed by Stacey Bros. Gas Construction Company, Cincinnati.

The old tank is literally boosted to new capacity height, as new rings are added at the base by a patented process which makes use of virtually all of the original structure in assembled form. Such re-use, along with the utilization of the original foundation and the minimum dislocation of connections, contributes much to the economy of the process as well as to the speed with which a job may be completed. The method will be particularly useful where facilities are crowded and there is room only for expansion upward.

As much as 100 percent additional capacity may be added by cutting the existing tank shell at the base, adding new radial plates, and building a new shell around the old structure to give the desired height. Water is then run into the tank up to the new shell level, so that compressed air may be introduced to float the old cover shell up to the new level. Various controls hold the tank steady and level to 1/16-inch, while 4-inch filler plates are inserted between the shells, and the two units are tack welded in place.

When air pressure is released, and the water drained from the tank, the two

Tested Ashore for Service at Sea...

Carrier type "9-J" condenser, equipped with Anaconda Cupro Nickel Condenser Tubes and Tube Sheets, and outside shell of Brass.

MEETING A "force test" of 400 lb. per sq. in. air pressure while immersed in water is a preliminary requirement for this type "9-J" refrigerating condenser. Pressure is then lowered to 250 lb. per sq. in. and the unit closely inspected for leaks.

Ability to meet this rigid test is assured in two ways . . . sound construction by the manufacturer, Carrier Corporation of Syracuse, N. Y., and the use of tough, corrosion-resistant Anaconda Alloys. Tubes and tube sheets are made of Cupro Nickel, and the outside shell is Brass.

In addition to service in LST's, the Carrier type "9-J" Condenser, with modified head plate, is also used in DE vessels.

For heat transfer service in the marine, power, petroleum, process and other fields, The American Brass Company manufactures a wide variety of Anaconda Copper and Copper Alloys in sheets, tubes and other forms. Equipment fabricators are invited to utilize the broad experience and metallurgical knowledge of our Technical Department in determining the most suitable alloys.

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Anaconda Condenser Tubes

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6 Weeks' Tie-Up averted by this 1 Day Repair with SMOOTH-ON

When this pump casing developed a long, diagonal crack, a 6 weeks' tie-up was threatened. But the engineers drilled and tapped both ends of the crack and inserted plugs to check spreading. Then they tamped the crack full of Smooth-On No. 1 Iron Repair Cement and drew the edges tightly together with staples fitted into holes drilled in the casting and anchored in with more Smooth-On. The whole job took less than a day, and the result was a pressure-tight repair.

This is the sort of speedy, economical, effective repair that Smooth-On No. 1 has been used for in refineries and other plants for 50 years . . . saving equipment replacements, time and money. Costs little, easy to use—no heat required—makes lasting repairs. Order Smooth-On No. 1 from your supply house. Sizes from 7-oz. up. If they haven't it, contact us.

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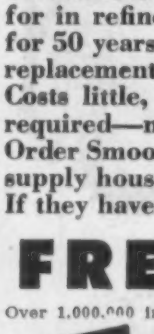
Over 1,000,000 in circulation. Describes industrial and home repairs of endless types. 40 pages, 170 diagrams. Pocket size. Handy index. Every engineer and maintenance man should have it. Send coupon for your copy.



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Do it with SMOOTH-ON

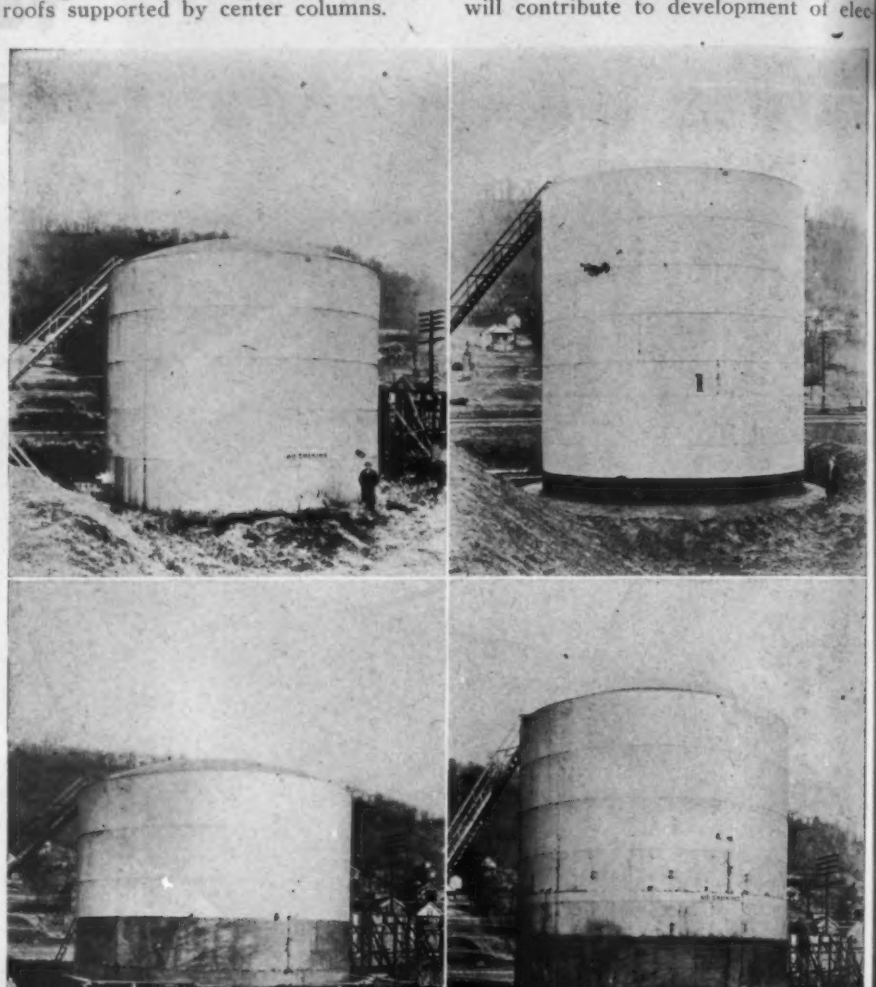
shell sections and fillers are completely seal welded on the outside. Inside, the old shell is trimmed and welded at intervals around its circumference, and the enlarged tank is ready for service.

Originally developed to obtain better buoyancy control of petroleum storage tanks in areas subject to flood, the new method can be used to build up tanks having either umbrella type roofs, or roofs supported by center columns.

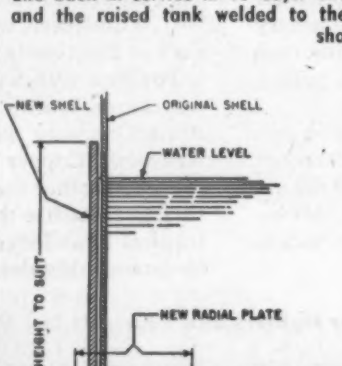
New Thermoplastic Announced by Monsanto

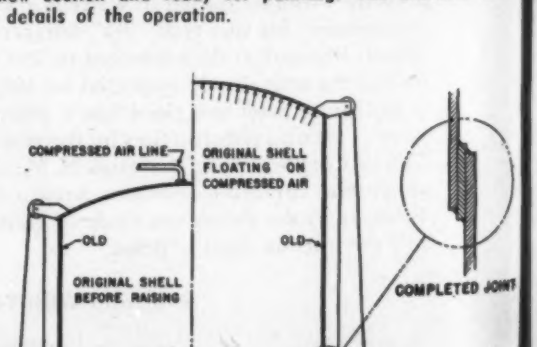
Monsanto Chemical Company has begun volume production of Styramic HT, a new thermoplastic with remarkable electrical insulating properties, after six years of research undertaken at the request of the armed services.

Predicting that the new thermoplastic will contribute to development of elec-



Top pictures show a 300,000-gallon tank (left) which has been enlarged to 425,000 gallons and back in service in 10 days. Construction pictures below show the new rings in place (left), and the raised tank welded to the new section and ready for painting. The sketches below show details of the operation.



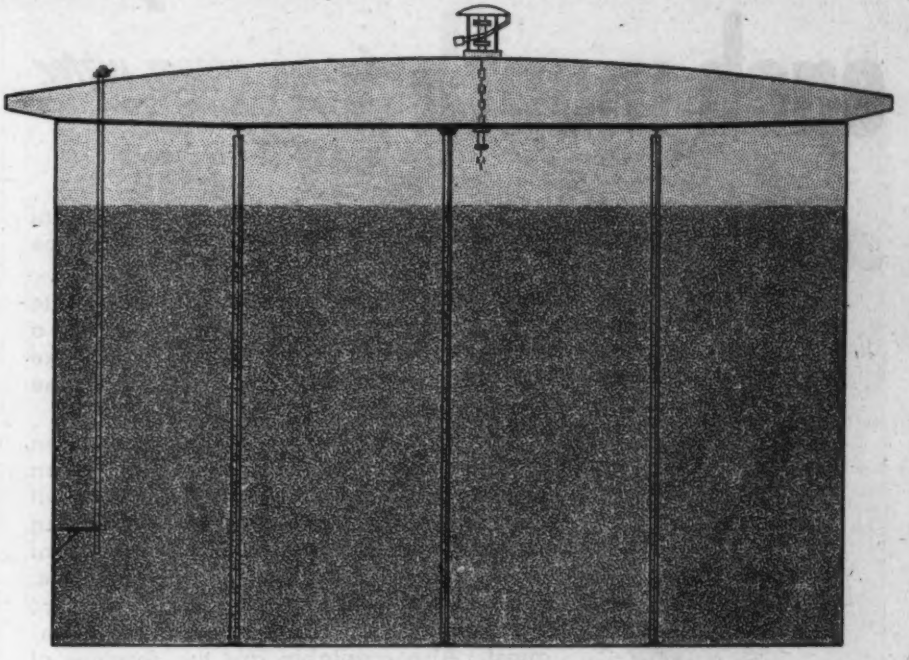


ll evaporation losses

Pressure charts show that the Wiggins Balloon Roof is an effective means of stopping evaporation losses in storage tanks containing gasoline.

■ The pressure charts reproduced at the left show how effective a Wiggins Balloon Roof is, in stopping evaporation from a storage tank containing gasoline. These charts record the pressures inside of a 90-ft. diam. by 60-ft. gasoline storage tank equipped with a Wiggins Balloon Roof at Rio de Janeiro, Brazil, during the three-week period from July 6th to July 27th, 1944, inclusive.

The tank has a capacity of 55,250 bbls. of 50 U. S. gals. The contents were held in standing storage except for five withdrawals of 40, 100, 510, 210 and 300 bbls. during the first week and two withdrawals of 1560 and 1770 bbls. the last 24 hours. The amount of gasoline in the tank remained constant at 84.5 percent of its capacity for 14 days. The temperature during the above mentioned period ranged from 58 to 84 degrees F.



■ *Above: A diagrammatic cross-section of the Rio de Janeiro tank with a Wiggins Balloon Roof. The dark tone represents gasoline, occupying 84.5 percent of the tank capacity. The lighter tone represents air vapor space. The Balloon Roof is shown fully expanded. (Wiggins Balloon Roofs over 60 ft. diam. are now built with a center cone section.)*

■ The Wiggins Balloon Roof is recommended for flat-bottom tanks of all sizes handling crude oil or motor fuel which are filled or emptied not more than six times per year. The balloon has sufficient capacity to prevent breathing losses even at times when the tanks are nearly empty.

The photo at the right shows a typical Wiggins Balloon Roof installation. This tank holds 30,000 bbls. and the Wiggins Balloon Roof is 90 ft. in diam.

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Chicago 4.....2463 McCormick Bldg.
Los Angeles 14.....1434 Wm. Fox Bldg.
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Tulsa 3.....1626 Hunt Bldg.
Cleveland 15.....2234 Guildhall Bldg.
New York 6.....3302-165 Broadway Bldg.
Philadelphia 3.....1608-1700 Walnut St. Bldg.
Washington 4.....703 Atlantic Bldg.

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AREA OF LEAK	AIR		STEAM		WATER	
Diameter Inches	Number of cubic feet per month at 75 lb. pressure	Total cost of waste per month 11c per 1000 cubic feet	Pounds wasted per month at 160 lb. pressure	Total cost of waste per month 65c per 1000 lb.	Gallons wasted per month at 60 lb. pressure	Total cost of waste per month 16c per 1000 gallons
1/2"	13,468,000	$1,481.44	1,219,280	$792.53	1,524,100	$243.86
3/8"	7,558,500	831.44	684,290	444.79	855,360	136.86
1/4"	3,366,990	370.37	304,820	198.13	381,020	60.96
1/8"	824,570	90.70	74,650	48.52	93,310	14.93
1/16"	213,000	23.43	19,280	12.53	24,110	3.86
1/32"	52,910	5.82	4,790	3.11	5,990	.96

What does it cost you each month *for air, steam, water, you never use?*

Fig. 1640 "King Clip" Gate

Maybe you've never checked the actual cost of valve leakage. If you haven't, you'll doubtless be startled at these figures.

A single valve leak the size of a pinhead can waste enough air in a month to approximate the cost of a new valve. Steam leaks . . . water leaks . . . also take a heavy toll if neglected . . . not to mention the wastage of such a critical item as fuel.

Where Lunkenheimer Valves are given ordinary care, such losses are held to an absolute minimum. These quality-built valves are designed to give extra long service with the lowest possible outlay of time, labor, and money, for maintenance. Enlarged copies of the above chart for posting in your plant are available on request. Also available are the services of your nearby Lunkenheimer Distributor, who is fully equipped to assist in solution of your operating or maintenance problems.

The Lunkenheimer Co., Cincinnati 14, Ohio, U.S.A. (Branch Offices: New York 13, Chicago 6, Boston 10, Philadelphia 7. Export Department: 318-322 Hudson St., New York 13, N. Y.)

Fig. 16-P Bronze Globe

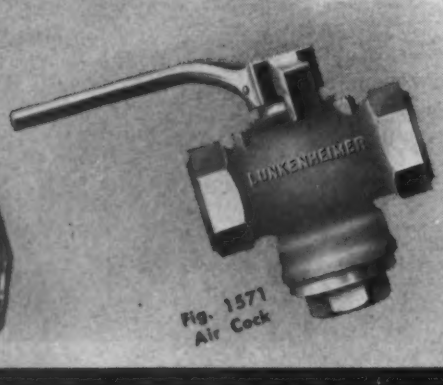

Fig. 1571 Air Cock

LUNKENHEIMER VALVES

BRONZE, IRON, STEEL AND CORROSION RESISTANT ALLOY VALVES, 125 TO 2500 LB. S.P.; BOILER MOUNTINGS, LUBRICATING DEVICES, AIRCRAFT FITTINGS

tronic devices, an announcement said Styramic HT holds shape and strength at relatively high temperatures yet can be molded by the fastest and most economical means. It combines this heat resistance with high insulating efficiency in uses such as radar, television and facsimile transmission.

Electronic researchers have long had at their command a rigid plastic insulating material with conductivity characteristics approaching those of Styramic HT. Yet this material starts to lose its shape at 168° F., whereas Styramic HT has a heat distortion point of 236 degrees. Certain ceramics and glasses, ideal as insulators, cannot be precision-molded or machined.

Styramic HT is being produced in a new plant, designed by Monsanto Chemical Company engineers for Defense Plant Corporation, which adjoins the company's Plastics Division properties at Springfield, Massachusetts. It is being operated by the company.

The new thermoplastic was developed at the Springfield research laboratories of the company as one of the results of the research program begun in 1939.

As has been the case since production of Styramic HT was started in pilot-plant quantities, the entire output will go to the military until its needs cease to exist.

Styramic HT is the second new thermoplastic announced by the company in the last year. Also limited to military applications is its companion product, Cerex, which likewise withstands boiling temperatures and can be molded by speedy and inexpensive methods. However, Cerex is less suited to special electronic uses.

Styramic HT, with low yields from base materials and with its complexity of manufacture, cannot at present be projected as a product likely to achieve low cost in the immediate postwar era. Indications are it will go largely into specialty uses where performance rather than price is the dominant factor, it was said.

Patterson-Kelley Company Gets Army-Navy E Award

The Patterson-Kelley Company, East Stroudsburg, Pennsylvania, was awarded the Army-Navy E award at ceremonies May 22.

Pump and Air-Compressor Handbook

Edited for the non-technically educated mechanic or operator of pumps or compressors, Audel's Pumps, Hydraulics, Air Compressors, compiled by Frank D. Graham and published by Theo. Audel & Company, 49 West 23rd Street, New York 10, (price $4.00) discusses design and operating problems through the question-and-answer method, with many line drawings and parts illustrations to bring out the details involved.

The book is divided into three parts, the first discussing pumps, their applications, and auxiliaries; the second section is more directly a discussion of hydraulics; while the final or third part deals with air compressors and equipment used with them.

A compendious index, covering 24 pages, aids the beginner in finding that particular portion of the handbook which is most directly applicable to his problems.

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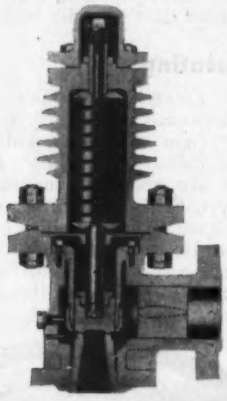
1—Relief Valve

Crosby Steam Gage & Valve Company, 165 Broadway, New York 6, announces addition of a new style, JJAD, to its line of nozzle relief valves. The new valves are designed for operating temperatures above 1000° F., and particular attention is paid to design of seat contours and selection of materials. Full nozzle and solid disc construction is employed, both parts being alloy steel. While the valve is closed, the nozzle and disc are the only parts under pressure. Seats on both nozzle and disc are flat, and flow of discharging media is parallel to the seats, minimizing possibility of cutting or erosion. Bodies and bonnets are of alloy steel with cooling pins cast on the bonnets for heat radiation and to protect the tungsten-steel from excessive temperatures. Hot fluids are prevented from reaching the spring by means of a cover plate at the top of the stainless-steel guide.



Crosby Style JJAD

Pressure limits vary from 1200 pounds at 1100° F. in 1½-inch size, to 450 pounds at 1100° F. in 6-inch size. Pressure limits for higher temperatures are proportionately reduced.

2—Electrode

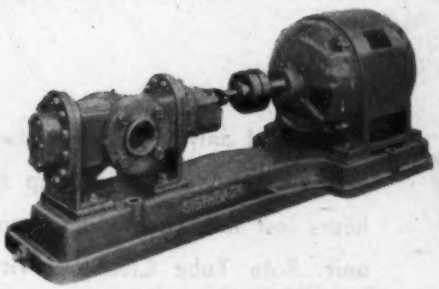
General Electric Company, Schenectady, New York, announces a new heavily covered arc-welding electrode for welding low-alloy, high-tensile steels. Specially designed for use on carbon-molybdenum steel in the high-pressure piping industry, this electrode also may be applied to vessels (fittings) and structural weldments of innumerable kinds.

Known as Type W-56, the new electrode operates satisfactorily on either alternating current, or direct current, reverse polarity, and its range of current is sufficiently broad to cover a wide range of plate thicknesses. A medium-long arc is recommended for best results with this electrode. It can be used in the flat, vertical, and overhead positions. Moreover, it produces a relatively flat deposit, particularly in the vertical position.

Features of the new electrode include a stable spray-type arc, deep penetration, and excellent creep-resisting qualities. In addition, the covering used produces an easily removed, light, friable slag, which sets up fast, thus facilitating proper manipulation of the electrode. Available in sizes ⅛- 5/32- and 3/16-inch in diameter, the new electrode meets the requirements of AWS Classes E7010/E7011 and complies with the Navy Bureau of Ships specifications 46E2.

3—Screw Pump

Sier-Bath Gear Company, 9274 Hudson Boulevard, North Bergen, New Jersey, has introduced a displacement pump of the screw type for handling thick liquids of either lubricating or non-lubricating type.



Sier-Bath Screw Pump

The internal gears require only an occasional packing-ring renewal which can be made while the pump is in service. Self-centering herringbone timing gears prevent side wear of screws resulting from contact while pumping. End-to-center flow of fluid in the horizontally-mounted units eliminates thrust bearings.

4—Relief Valve

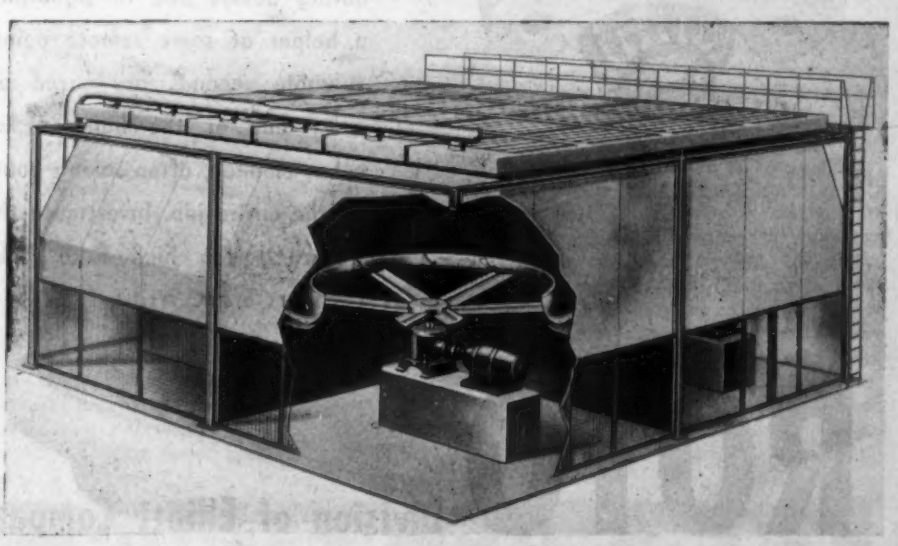
Farris Engineering Company, 345 Commercial Avenue, Palisades Park, New Jersey, has announced availability of a relief valve developed first for use on ships. In this valve, Type 1000, the diaphragm seals from leakage around the stem, which makes it suitable for service where there is fluid constantly on the downstream side. The valve will open to full relieving capacity at 20 percent over pressure, because it opens as a result of pressure on the diaphragm rather than on the disc. It closes at the set pressure. These features are said to make this valve particularly applicable where the relief valve is to be used for controlling pressure at the relieving point.

Farris Type 1000

Bulletin on this and other relief and safety valves manufactured by this company is available.

5—Cooling Unit

The Fluor Corporation, 2500 South Atlantic Boulevard, Los Angeles, has announced a fin-fan cooling unit in which cooling sections employ K-fin tubes which are cooled by forced draft fed by air from the cooler layer at ground level and supplied by fans with variable-pitch blades and with vari-



Fluor fin-fan cooling unit

A delay of only a second or two at each tube, can mount up to hours lost in cleaning a tubular unit. Roto Tube Cleaners, with operating air valve on the motor, enable the operator to control the equipment by himself. By eliminating delays due to signalling a helper at some remote point, valuable seconds are saved on every one of the hundreds of tubes cleaned, often saving hours on the entire job. Investigate the advantages which Roto Tube Cleaners offer. Write.

ROTO Division of Elliott Company

145 Sussex Avenue • Newark 1, N. J.

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able-speed drive. Vertical air flow against static head assures even air distribution over cooling surfaces. Units are designed for pressures to 5000 pounds per square inch and temperatures to 1500° F. Coils are located to provide sufficient static head for pump suction. Tubes can be removed and replaced quickly, and all mechanical equipment is readily accessible from the ground.

The Griscom-Russell Company collaborated in development of the unit.

A bulletin describing construction and application of this unit is available.

6—Rotating Seal

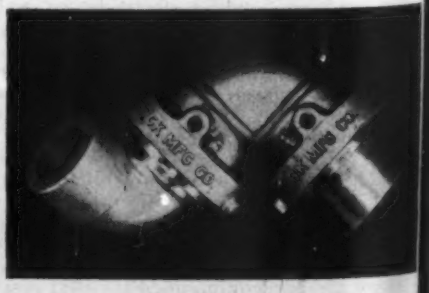
Cook Electric Company, 2700 Southport Avenue, Chicago 14, has developed a new type rotating seal, called the "Spring-Life Gyro Seal." No auxiliary springs are required in the application of "Gyro-Seals" because the inherent spring rate of the bellows is, in most cases, sufficient to maintain the required pressure on the sealing surfaces. The bellows can be made of all types of metals

Cook Spring-Life "Gyro-Seal"

to suit the conditions of each application. "Gyro-Seals" will operate on both external and internal pressure, and have been built to withstand 5000 pounds per square inch pressure in a range of from slower than 1 to faster than 4000 revolutions per minute. Lapped finishes of the sealing members can be furnished to meet specifications wherein one light wave of flatness is required.

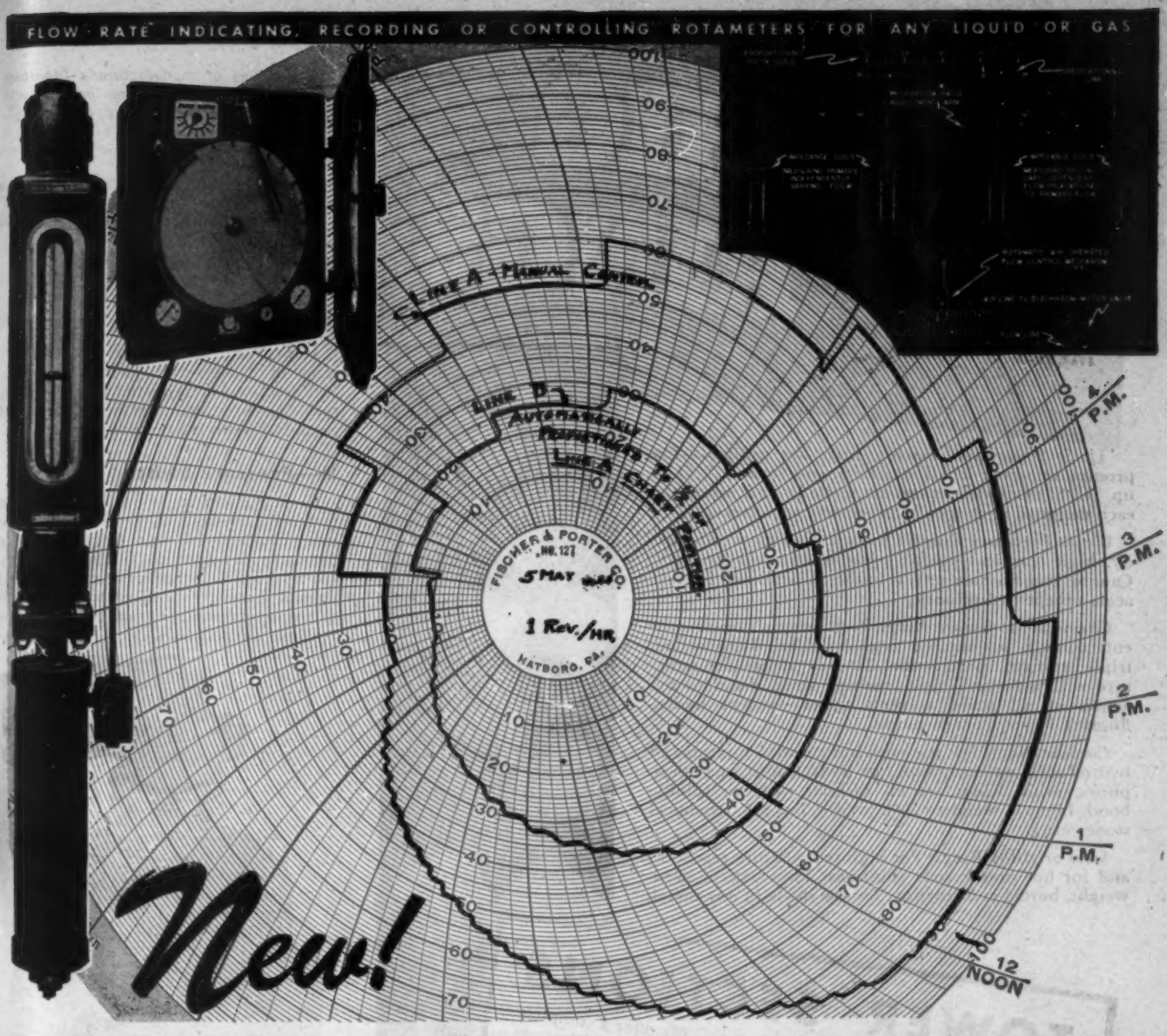
7—Swivel Joint

G-K Manufacturing Company, Box 5187, Houston, has placed on the market a new line of high- and low-pressure steel swivel joints, featuring an extrudable plastic packing similar to that used in high-pressure valves. The use of plastic packing provides a complete sealing action for the joints, it is claimed.



G-K Plastic-Packed Swivel

FLOW · RATE INDICATING, RECORDING OR CONTROLLING ROTAMETERS FOR ANY LIQUID OR GAS



ROTAMETER FLOW RATIO CONTROLLER

automatically proportions two flows with high accuracy!

If you have a ratio flow control problem where you wish to keep one flow at a fixed percentage of a second *variable* flow, the new Rotamatic Ratio Flow Controller will do the job automatically for you. Furthermore the ratio may be varied at will by a turn of the flow ratio button. The device for doing this remarkable job of proportional control is so simple and so positive that what was once a difficult control problem has become easy and also reasonable in price.

In the flow chart shown above, the ratio index button has been set for proportioning at 1:2. Notice how accurately this proportion has been maintained, in spite of rapid flow fluctuations and variations over the full flow range of the rotameters.

The Ratio Controller operates as follows: Two rotameters with electric transmission for remote reading are placed in the respective flow streams. The remote flow-responsive balance beams from these two rotameters are placed back to back and connected by a cross beam, as shown in the above sketch. From this cross beam is suspended an arm whose position may be changed at will by sliding it on the beam. This suspension arm is connected to a Rotamatic air-operated control mechanism which in turn transmits air pressure to an air-operated valve in the flow line of the stream which is to be maintained at a fixed percentage of the main flow. It can be seen that the position of the arm suspended on the cross beam determines the control point or in other words, the flow ratio of one stream to the other. Liquid flows from 1GPM up to 6,000 GPM may be proportioned, and gas flows in equivalent volumes.

The full and interesting details in regard to the new Rotamatic Ratio Controller are told in our bulletin 50-A which we will send to you without any obligation. Owing to the paper shortage, please make your request upon your Company letterhead. Write to FISCHER & PORTER COMPANY, 1906 County Line Road, Hatboro, Pa.

FISCHER & PORTER COMPANY

RASCHIG RINGS

"U. S. Stoneware" raschig rings are available for prompt shipment in all standard sizes from ¼" O.D. up. "U. S. Stoneware" rings are made in four materials, each designed to fit specific processing requirements:

White Porcelain Rings: Characterized by zero-porosity, high chemical purity, great mechanical strength. Cannot contaminate any solution. Unaffected by any acids except hydrofluoric.

Chemical Stoneware Rings: Non-porous, non-absorbent, contain no soluble organic filler. Thin-walled, triple strength construction. Dense, granite-like structure will withstand high crushing stress. Inert to the action of all acids, solvents, gases (except hydrofluoric) in any concentration.

Carbon Rings: For use with hot caustics, mixtures of hydrofluoric and sulphuric, or hydrofluoric and phosphoric acids. Rings are all carbon, with no soluble bond. Light in weight (20% to 30% less than chemical stoneware).

Steel or Alloy Rings: For high temperature reactions, and for hot caustic soda solutions. Thin-walled, lightweight, butted construction. Can be made in any metal.

TOWER SECTIONS

We offer a complete line of chemical stoneware Tower Sections, in standard or Cera-therm-500 heat-shock resistant bodies — including saucers, covers, distributors, supporting plates, etc. Standard sizes 8" to 60" I.D. Special sizes on order.

FREE: Big, new 16-page bulletin on Tower Packing and Tower Construction. For your free copy write The U. S. Stoneware Co., Akron 9, Ohio.

U. S. STONEWARE

AKRON, OHIO

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whether the equipment is operating under pressure or vacuum.

A simple quarter-turn on the packing screws applies additional packing, if needed, to the packing gland.

Construction of the joints which makes locking and bearing elements easily accessible for adjustment or replacement on the job.

Joints are immediately available in sizes of 2-, 2½- and 3-inch with 1-, 2- and 3-way swivels tested for 1000 pounds for low-pressure service and 10,000 pounds for high-pressure service.

8—Pressure Switch

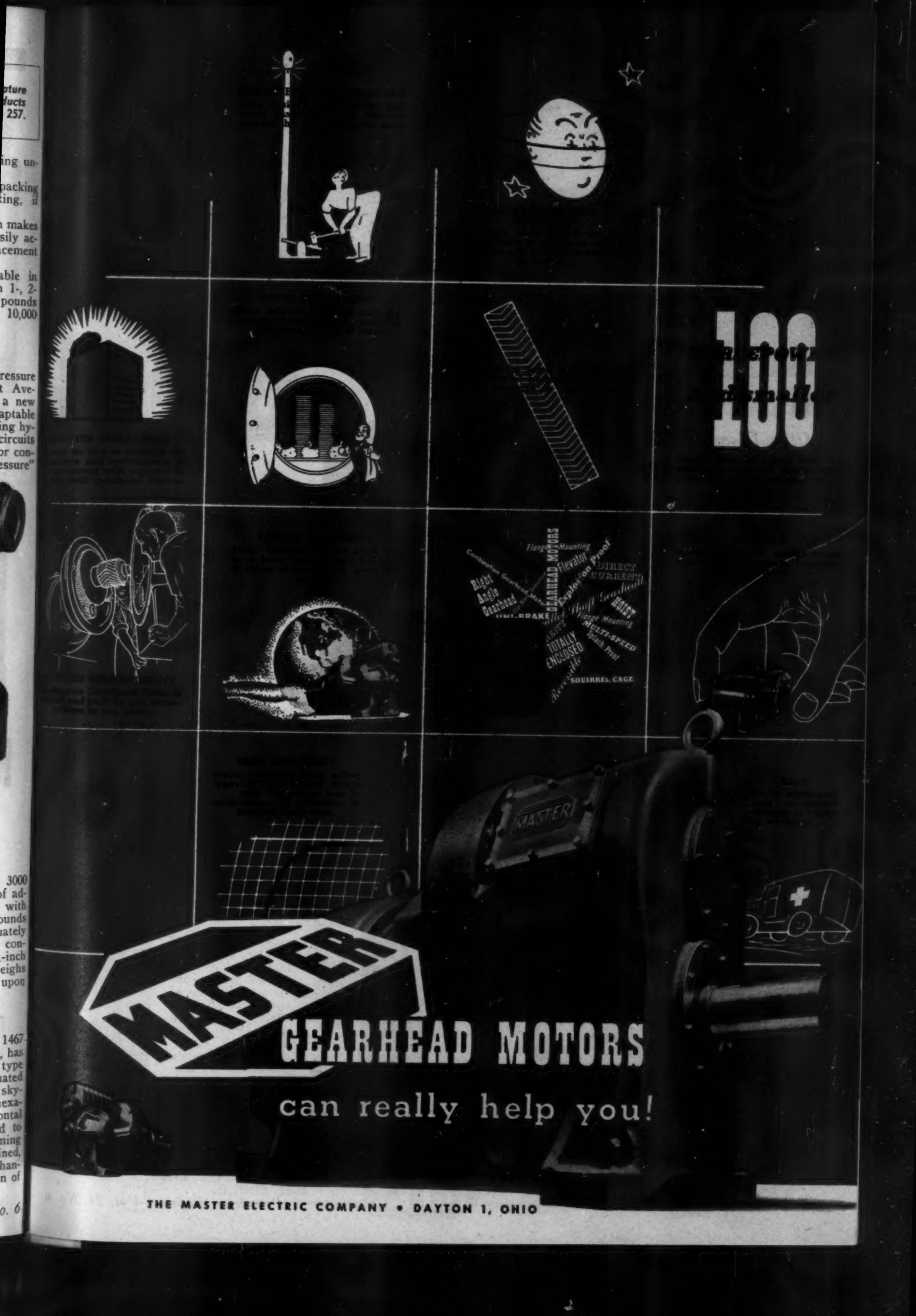
Cook Electric Company, Pressure Switch Division, 2700 Southport Avenue, Chicago 14, has developed a new pressure detector particularly adaptable for hydraulic systems for controlling hydraulic pressures and cutting off circuits at predetermined pressures, and for controlling surge loads. This "Hi-Pressure"

Cook "Hi-Pressure" Switch

switch is capable of withstanding 3000 pounds surge load, with a range of adjustment from 100 to 2000 pounds with a 20-pound differential at 100 pounds pressure which increases proportionately at higher pressures. The pressure connection can be either ⅜- or ⅛-inch standard pipe thread. The switch weighs approximately 2 pounds, depending upon the type of fittings.

9—Smoke Stack

Chicago Fire Brick Company, 1467 Elston Avenue, Chicago 22, Illinois, has announced development of a new type of smoke stack, which it has designated "Durabilt." Built like a modern skyscraper, it consists essentially of a hexagonal steel structure to which horizontal and vertical members are attached to support tile members. Each tile forming the inner wall is individually retained, and the outer tile is supported by channels at definite spacings. Any section of


100
Flange Mounting
Elevator
DIRECT CURRENT
Explosion Proof
Right Angle Gearhead
GEARHEAD MOTORS
Shaft Gearhead
Flange Mounting
MULTI-SPEED
Splash Proof
TOTALLY ENCLOSED
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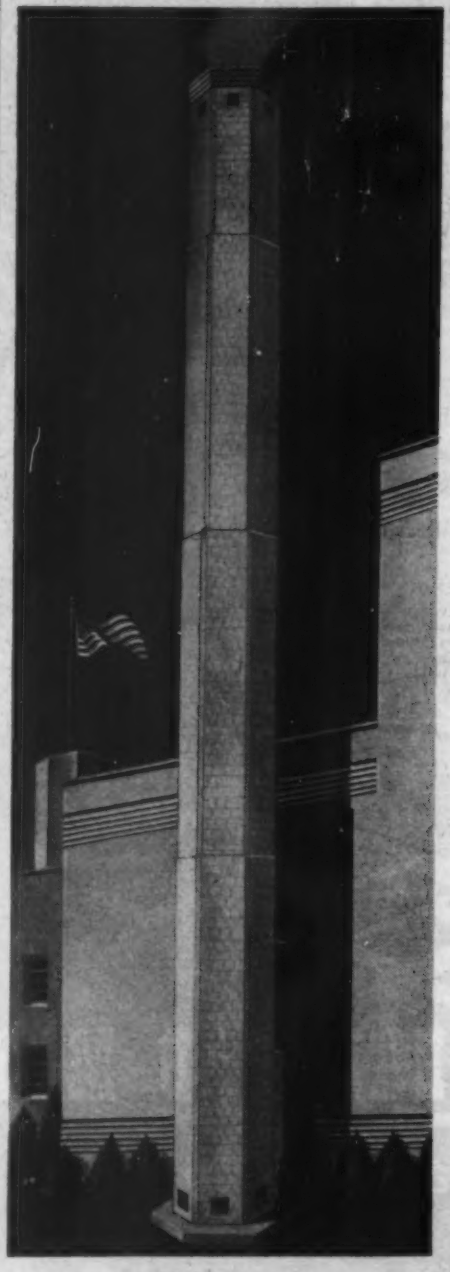
tile may be independently removed without affecting the others.

Insulation fits snugly and securely between the tile and retainer castings, providing low radiation loss, tending to keep the temperature within the stack uniform, thereby increasing efficiency by improving draft.

Being sectionally supported, there is no cumulative load upon the firebrick lining. Weight savings of approximately 33⅓ percent are possible, with comparable reduction in foundation requirement.

The outer casing of the stack can be of tile, sheet steel or waterproof plaster. Air space is provided between the insulation and outer tile throughout the stack, with vents at top and bottom.

The stack can be erected in any height from 50 to 300 feet.



"Durabilt" Stack

10—Amplifier

Commercial Research Laboratories, Inc., 20 Bartlett Avenue, Detroit 3, Michigan, recently has announced production of a laboratory type amplifier, designated

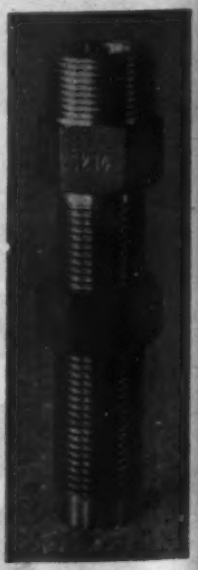
COX Type 2

COX Type 2, having the following specifications:

Number of Stages	3
Overall Gain	80,000 (98 db.)
Second Stage Input Gain	1,850
Input Impedance	
1-A—(80,000 Gain)	500,000 ohms
1-B—(80,000 Gain)	90 megohms
2—(1,850 Gain)	500,000 ohms
Output Impedance	50,000 ohms
Output Voltage (R.M.S.)	70 volts
Harmonic Distortion (max.)	3%
Frequency Range (10%)	1 to 15,000 cps
(Usable to 100,000 cps)	
Calibrating Voltage	0 to 1,000 m.v.
Power Supply	50 to 60 cps
Electronic Regulation	95 to 130 volts
Consumption	60 watts

11—Quartz Pressure Element

Commercial Research Laboratories, Inc., 20 Bartlett Avenue, Detroit 3, Michigan, has announced the COX Type 3 quartz pressure element for dynamic pressure study. It is designed to convert mechanical pressures into electrical impulses which may be amplified and pictured on the screen of a cathode-ray tube. It may be used with auxiliary equipment for studying combustion balance under all conditions of operation, also the effect of changes in carburetor adjustment, and carburetion and ignition characteristics during successive cycles.



COX Type 3

When used with a properly designed amplifier, it may be used at approximate frequencies of 10 cps or higher with inappreciable error.

Each unit is given an individual cali-

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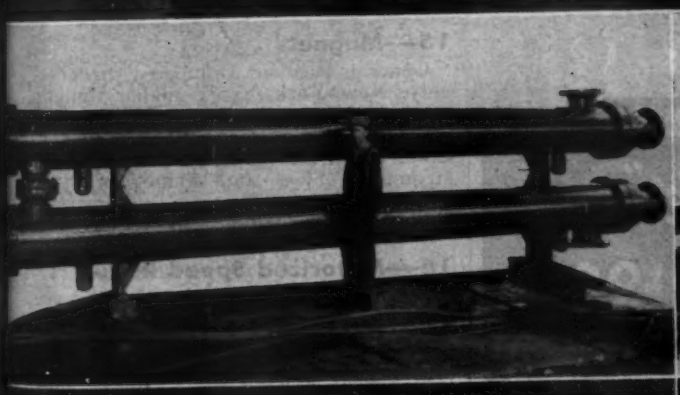
heat exchangers, reboilers, jacket water coolers, condensers, shell and tube, atmospheric and submerged types. Among important installations are 100 octane gasoline and synthetic rubber plants.



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Hicks welds copper, copper alloys, steels, aluminum, magnesium and other metals.

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Highly Efficient at all Temperatures up to 1600° F
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KEL-BLOC the ONE BLOC INSULATION is effective over the entire temperature range up to 1600° F.

Kel-Bloc is made from high temperature, moisture resistant long fibre black Rockwool, felted and bonded together by a special method which eliminates all voids and provides uniform stratification.

This light weight, insulating block has exceptionally low conductivity—due to the millions of dead air cells—and also has a low alkalinity factor remaining unaffected when exposed to moisture or high humidity.

A request for additional information will receive prompt attention.

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bration in terms of millivolts per 100 pounds of pressure per square inch.

Available in 18—1¼ mm thread; other sizes can be fitted with adapters.

12—Bellows

Cook Electric Company, 2700 Southport Avenue, Chicago 14, has available a handsome brochure on its "Springlife" metal bellows, including engineering and application data.

13—Remote Mechanical Control

M. L. Bayard & Company, 1902 Indiana Avenue, Philadelphia 32, announces a new manual, Bulletin A-100, describing standard related units of a remote mechanical control system of new design. Specification and capacity charts are given for the universal shaft assembly, steady shaft assembly, and bevel gear assemblies. In addition are details on layouts for arrangement of these units for operation of large valves, ventilators, etc.

14—Steel Tubing

Michigan Seamless Tube Company, South Lyon, Michigan, has available in a bulletin "Weight Tables . . . Round Seamless Steel Tubing," the indicated data on all sizes of tubing.

15—Magnets

General Electric Company, Schenectady, New York, has available Bulletin GEA-3682-B on sintered-alnico magnets, which describes manufacture and application of these magnets for use in instruments. Sizes and shapes of stock sizes are listed with prices, and special shapes are available.

16—Motorized Speed Reducers

Philadelphia Gear Works, Erie Avenue and G Street, Philadelphia 34, is distributing a new 52-page catalog which describes its line of self-contained motorized speed-reducing units. These units are built in a wide variety of sizes and ratios, in both horizontal and vertical types. Complete engineering data is contained in this new catalog.

17—Branch Pipe Outlets

Bonney Forge & Tool Works, Allentown, Pennsylvania, has issued a 32-page handbook which illustrates and explains installation of pipe outlets by the "WeldOlet" method. Also shown are tools needed, types of fittings available, and typical installations.

18—Solenoid Valves

Automatic Switch Company, 41 East 11th Street, New York 3, has issued Circular No. 200 which discusses generally many types of solenoid valves it manufactures for automatic and remote control of the flow of liquids and gases.

19—Temperature-Control Cabinets

Precision Scientific Company, 1750 North Springfield Avenue, Chicago 47, has issued Catalog 325, containing 48 illustrated pages pertaining to "Precision"-Freas constant-temperature-control cabinets, including an extensive variety of standard models, as well as many photo-

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for the RIGHT ANALYSES in Tubing for ANY KIND of SERVICE

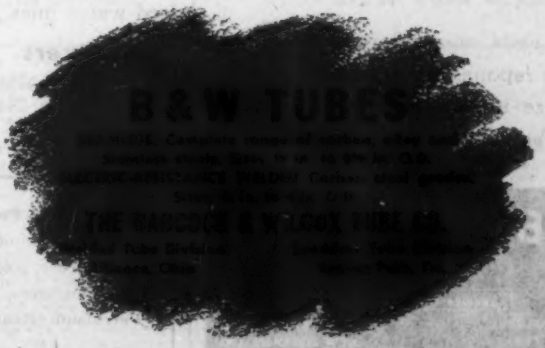
In matching tubes to today's refining and processing operations, B&W Croloys provide you with a complete range of steel analyses from which you can be sure of getting the correct tubing for any specific requirement.

Because performance of Croloy tubing can be predicted in the laboratory with unvarying accuracy, you can depend on it to give long life, dependable service at low ultimate cost on the job.

B&W low and intermediate Croloys have been developed expressly for applications requiring resistance to high temperatures, high pressures, corrosive attack, creep strength and all other adverse conditions. They are in wide use today in refineries, synthetic rubber plants and chemical industries, giving highly satisfactory and economical results.

Among B&W Croloys there is ample selection to assure the best alloy for any given condition. Data on creep strength, tensile strength and other physical characteristics are available to help you determine the tubing best suited for each job. So is the cooperation of B&W engineers. When you call on Croloy, you call on their advice and assistance backed by long experience in successfully solving tough tubing problems.

CROLOY 1¼	CROLOY 2¼	CROLOY 3 M
Economic grade good creep strength properties. Somewhat more corrosion resistant than the chromium free steels.	*Exceptionally high creep strength* for polymerization and high pressure cracking. Otherwise similar in properties and characteristics to Croloy 2.	Somewhat better creep properties and better resistance to corrosion and oxidation than Croloy 2.
CROLOY 5	**CROLOY 7**	**CROLOY 9**
For operating conditions where corrosion resistance is primary requirement—provides good creep strength and oxidation resistance superior to Croloy 2.	Intermediate steel between Croloys 5 and 9 for operating conditions where corrosion resistance is the primary requirement. Somewhat more oxidation resistant than Croloy 5.	For severe operating conditions where high corrosion and oxidation resistance are essential—suitable for hydrogenation processes.
CROLOY 18-8S	**CROLOY 18-8SCB**	**CROLOY 25-20**
Practically unaffected by extremely corrosive oils at high temperatures. Has high creep strength and high resistance to oxidation.	Similar in properties to CROLOY 18-8S but stabilized with columbium, making it adaptable for welding or heating in carbide range.	For extreme resistance to oxidation and corrosion, for high-pressure, high-temperature services, as in hydrogenation, polymerization, and special heat-resisting installations.



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Emulsified asphalt containing asbestos fibers—will not support combustion — long durability — dries smooth and black.

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GULF ENGINEERING CO., INC.

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graphs of constant-temperature cabinets and baths built to specifications. Standard cabinets include electrically-heated ovens for laboratory drying operations, plastics, preheating, conditioning, rubber aging; sterilizers, incubators, paraffin embedding ovens, low-temperature cabinets, humidity-control cabinets; steam-heated explosion-proof cabinets; vacuum ovens and combustion-tube furnaces for laboratory use. Included also is general information pertaining to mechanical and gravity convection heat transfer. Catalog is accompanied by price list.

20—Gas-Testing Apparatus

The Refinery Supply Company, 621 East Fourth Street, Tulsa 3, Oklahoma, has available a new catalog, No. 30-A, on gas-testing apparatus. Items described include recording gravitometer, gas gravity balances, dew-point tester, vapor-pressure bomb, specific-gravity bomb, dead-weight-testing instruments, pulsameter, etc.

21—Insulating Brick

Harbison-Walker Refractories Company, 1800 Farmers Bank Building, Pittsburgh 22, has issued a colorful brochure on "Five Insulating Brick of Prime Importance to Refractory Users." Included are tables and charts showing heat losses, heat-storage capacities, and thermal conductivities.

22—Heat Transfer Equipment

The Whitlock Manufacturing Company, 48 South Street, Hartford 1, Connecticut, is distributing Bulletin No. 645, which gives illustrated descriptions of its heat exchangers, heaters, coolers, coils and bends of pipe and tubing, pressure vessels and prefabricated plate products. Engineering data includes tables of heater specifications and capacities.

23—Insulations

Baldwin-Hill Company, 501 Klagg Avenue, Trenton 2, New Jersey, is distributing a handsome brochure on industrial insulations. Engineering data includes information on efficiency of the several products offered for specific applications and methods of applying.

24—Chemical Feed Systems

Milton Roy Pumps, 1300 East Mermaid Avenue, Philadelphia 18, has available Bulletin 451, on chemical feed systems for boiler-water treatments, which gives data on "simple, complete, 'packaged' units for feeding directly into boiler drums . . . for feeding into boiler-feed-water lines."

25—Mixers

The Turbo-Mixer Corporation, 247 Park Avenue, New York 17, is distributing Bulletin 11 on Turbo-Mixers for mixing liquids with liquids, solids, and/or gases. In addition to detailing applications and mechanical excellence, in engineering approach it discusses the mechanical and chemical aspects of mixing.

Centrifugal Pump Engineer able to take charge of design of pumps for refinery use. Record of experience should be submitted. Address: Box 70, c/o Petroleum Refiner, Houston, Texas.

26—Cylinder Packing

Darling Valve & Manufacturing Company, Williamsport, Pennsylvania, has issued a new bulletin, No. 4502, which gives data on use of "Darcova Pumcups" in air and hydraulic cylinders. Data also is included on special pistons available for this service, as well as for reciprocating pumps. Information on "Darcova

We design and construct all types of modern refining units.
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TRADE MARK REG. U. S. PAT. OFF.

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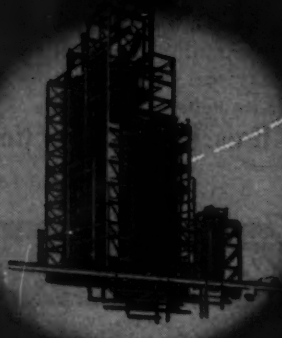
LIQUID CAUSTIC POTASH



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New York 6, N. Y.	40 Rector Street
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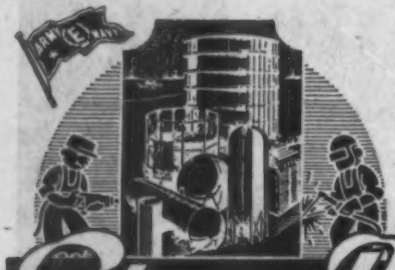

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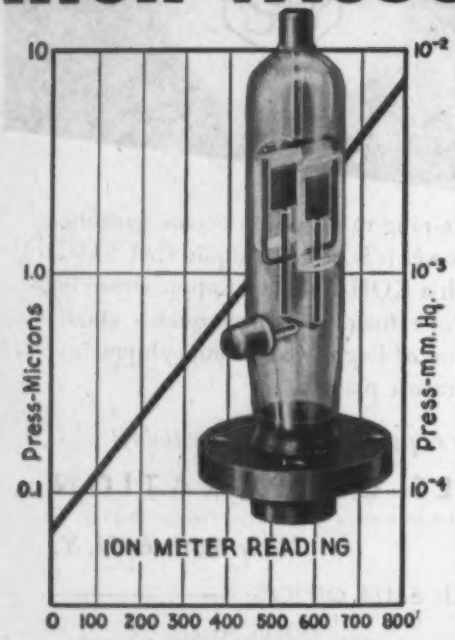

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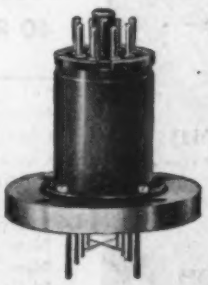
Measures low pressure levels with millivoltmeter which indicates variation in thermocouple voltage due to changes in vacuum. Ideal for systems requiring rapid verification of high vacuums. Heater and instrument terminals fit standard 8-prong tube socket.



UNIVERSAL X-RAY PRODUCTS INC.

1800-L N. FRANCISCO AVENUE • CHICAGO 47, ILLINOIS

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Pumcups" in the latter application is contained in the company's Bulletin No. 4401.

27—Cathodic Rust Prevention

The Johnston & Jennings Company, 864 Addison Road, Cleveland 14, Ohio, has issued Bulletin R-181, which describes "Rusta Restor," a cathodic method for preventing rusting of steel tanks, piping and structures. Included are descriptions of simple laboratory experiments showing electrical control of oxidation, and description of the equipment.

28—Compressors

Davey Compressor Company, Kent, Ohio, has available a bulletin giving engineering and construction details of its line of portable and industrial air compressors, including those operated by truck power take-offs.

29—Electronic Controls

Wheelco Instruments Company, Harrison and Peoria Streets, Chicago, has issued a new 12-page catalog on electronic controls, listing principal items supplied by the company.

30—Tank Construction

The Stacey Bros. Gas Construction Company, 5535 Vine Street, Cincinnati 16, Ohio, has available its General Bulletin G-45, which in 44 pictorial pages shows the company's facilities for fabrication and erection of gas holders, storage tanks, processing vessels, and other structures.

31—Steam-Jet Ejectors

Ingersoll-Rand Company, 11 Broadway, New York 4, has issued a new bulletin on steam-jet ejectors. Operating characteristics, principles and features are given, as well as construction details and schematic diagrams of various single- and multi-stage setups, with and without intercondensers, pre-coolers and after-condensers. Photographs show the line of ejectors and accessories as well as typical industrial installations.

32—Filter-Lens Chart

American Optical Company, Southbridge, Massachusetts, is distributing a reference chart for welders which points out the proper shades of filter lenses to wear for different types of welding operations.

33—Temperature Transfer

The Dow Chemical Company, Midland, Michigan, has available a brochure, "The Dowtherm Story," which discusses use of Dowtherm A in process work, and tables showing the thermodynamic properties of this substance.

34—Acid-Proof Cement

Quigley Company, 527 Fifth Avenue, New York 17, is distributing an illustrated folder, Bulletin A.P.122, on acid-proof cements. It features particularly a quick-setting product recently developed.

35—Rotary Dryers

Louisville Drying Machinery Company, 450 Baxter Avenue, Louisville 4, Kentucky, is distributing Bulletin No. 53, which describes its steam-tube rotary dryers.